EYE HAZARDS IN INDUSTRY

BY LOUIS RESNICK

Published for the National Society for the Prevention of Blindness

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EVERY thirty seconds throughout every single working day an American workingman clasps his hand in pain to his eyes, the victim of an injury that could have been prevented. Today and every day of the working year, 26,880 workers are idle because of eye injuries. At the end of each working year one hundred more American workingmen have unnecessarily lost the sight of both eyes, as the result of occupational hazards, and one thousand more have needlessly lost the sight of one eye.

The total number of unnecessary eye injuries in American industry each year is estimated to be more than three hundred thousand. The total *compensation* cost to industry itself of these preventable injuries is believed to be more than $100,000,000, but only 20 percent, or 60,000 of these eye injuries are *compensable;* and it is estimated that the cost of the 240,000 so-called trivial eye injuries is more than $10,000,000 a year.

The workingman who loses one eye may receive as much as $2,000 compensation. On the other hand the workingman who loses the sight of both eyes may be forced to adjust his standard of living and that of his family to an income of as little as $30.00 a month for the rest of his life. There is no question but that the vast majority of eye injuries are preventable. Also, the return on investments in eye accident prevention is proportionately greater than the dividends of the primary business of industry itself.

There is no need for the blinding of any worker in American industry. The causes of industrial accidents and diseases affecting the eyes are now known. Methods of eliminating these hazards or of protecting workers against them have been thoroughly demonstrated. Devices to protect the worker against every type of eye accidents are now available.

The responsibility for putting these eye-protecting methods and devices into effect belongs equally

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IN INDUSTRY

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EXTENT, CAUSE, AND MEANS OF PREVENTION

By Louis Resnick

Published for the

NATIONAL SOCIETY FOR
THE PREVENTION OF BLINDNESS

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PREFACE

THE NATIONAL SOCIETY for the Prevention of Blindness has been concerned with the eye hazards of industrial occupations for more than a quarter of a century. This concern has been serious and active, not academic. As early as 1917 this organization published the first handbook dealing with these hazards, a volume compiled by Gordon L. Berry. In 1924 a revised and substantially enlarged edition was published, entitled *Eye Hazards in Industrial Occupations,* under joint authorship of the undersigned and the author of the present volume. In the intervening fifteen years much has happened to justify even more intensive activity of the society in this field. Old hazards have been eliminated or effectively guarded against, and new hazards have arisen. Progress has been made in many directions, and new problems have developed.

Today the National Society for the Prevention of Blindness is more than ever concerned with the eye hazards of industrial occupations, because despite all the progress that has been made toward their control these hazards still constitute one of the principal causes—if not the one most serious cause—of blindness and defective vision.

This society has throughout the past quarter century coöperated with the National Safety Council and with other national and regional safety organizations in their programs for sight conservation in industry. Substantial contributions toward the elimination of industrial eye hazards have been made by the Safety Council, the United States Bureau of Standards, and various other safety organizations. These agencies, however, of necessity direct

their activities primarily against the whole field of accident prevention and health promotion, a field in which eye protection is only one of scores, if not hundreds, of problems. Furthermore, a very large part of American industry—particularly in small plants—is still largely apathetic toward the organized safety movement. Thousands of industrial concerns have no contact with any national or local safety organization. It is in these concerns particularly that workers are blinded, and others suffer partial but serious impairment of vision from causes which are wholly preventable. The National Society for the Prevention of Blindness seeks to bring information about eye hazards and means of their elimination to the owners, supervisors and workers in these plants as well as in larger industrial concerns which may already have well organized safety programs but nevertheless contribute to the annual toll of blindness and near blindness from preventable causes.

There is still another important reason for this society's concern with the eye hazards of industrial occupations. The problem of eye protection in industry is at innumerable points closely interwoven with the problem of preventing blindness from other causes with which this society is primarily occupied. The audience which this society strives to reach in the conservation of vision generally is in large part an audience which can also help eliminate or control the eye hazards of industry. This audience includes ophthalmologists, city, state, and Federal health and industrial department officials, industrial physicians and nurses, public health nurses, teachers and school administrators, as well as all those interested in the promotion of better lighting, better sanitation, and public and industrial health generally.

It is with profound sorrow that I must report in this Preface the untimely death of the author, Louis Resnick, on March 18, 1941. Despite a lingering illness he worked assiduously to finish this volume and just three days before his death completed the manuscript. More than twenty years of staff association with organizations professionally concerned with sight conservation and the

general safety movement, including the National Safety Council, the American Museum of Safety, the American Standards Association, the National Bureau of Casualty and Surety Underwriters, the International Labour Office, and the National Society for the Prevention of Blindness, kept Mr. Resnick in close touch with every facet of the large problem of eye hazards in industry and with every development in the many efforts to eliminate these hazards.

The author's contacts with the problem were not confined to the swivel chair, but took him directly into factories, mills, mines, railroad shops, utilities, and other work places throughout the country. These first-hand observations of the problem of sight conservation in American industries were supplemented by an extended European tour in which he had opportunity to study what was being done by the industries of England, France, Switzerland, and other European countries to guard the eyes of factory workers.

Much attention is given in this volume to the monetary cost of industrial eye injuries and eye diseases, and the reason for this emphasis is explained. In considering the high monetary cost of industrial eye hazards to employer and employee and the great possibilities for money saving there is danger of overlooking the social significance and the human implications of these hazards.

This volume not only lays bare the eye hazards present in industries and occupations of all sorts but also reports on the measures that may be taken to eliminate these hazards and to guard workers against those which cannot be eliminated.

It is the hope of the sponsors of this volume that it will serve not only as a handbook for safety engineers, safety inspectors, and all others actively engaged in accident prevention generally and sight conservation in particular or in industrial efficiency, but also as a textbook by engineering schools, vocational training authorities, and all others engaged in preparing youth for work in industry.

At the moment and probably for years to come the country will

be engrossed in national defense. Conservation of the vision of American workmen is vital to national defense as are the building of armament and the training of men to use defense equipment. Good sight is a prerequisite to skilled craftsmanship, whether it be in the shop, in the field, in the air, or on the high seas.

LEWIS H. CARRIS
DIRECTOR EMERITUS
NATIONAL SOCIETY FOR THE
PREVENTION OF BLINDNESS

New York
June 15, 1941

ACKNOWLEDGMENTS

THIS BOOK represents the work not alone of the undersigned but also of many other persons professionally concerned with the prevention of blindness in industry and the general conservation of vision—safety engineers, physicians, surgeons, industrial executives, Federal and state government officers, insurance men, safety equipment manufacturers, dealers, consumers, and others.

The effort has been made to locate, study, and synthesize the best of all that has been written on the subject in recent years by men and women, here and abroad, out of their own experiences and observations. This editorial digest procedure was supplemented by numerous personal visits to industrial plants and by interviews with a large number of industrial workers who are exposed to eye hazards, with foremen and safety directors whose job is to protect workers from these hazards, and with doctors and nurses who try to save the workers' sight when their eyes have been injured by accident or disease.

The author is especially indebted to the late Dr. Park Lewis, Dr. Ellice M. Alger, Preston S. Millar, and Pauline Brooks Williamson, who as a committee of the Board of Directors of the National Society for the Prevention of Blindness read the manuscript, and also to John W. Avirett, 2d, president of the Maryland Society for the Prevention of Blindness, Lewis H. Carris, director emeritus of the National Society for the Prevention of Blindness, and to the staff of the same society, W. Graham Cole, director of safety of the Welfare Division of the Metropolitan Life Insurance Company, Dr. M. Davidson, ophthalmologist of the New York State

Department of Labor, and Dr. Leonard Greenberg, executive director of the Division of Industrial Hygiene of the New York State Department of Labor, for reading the manuscript, and to the author's son, William S. Resnick, for assistance in the research incident to this volume.

LOUIS RESNICK

New York City
March 15, 1941

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THE PROBLEM OF EYE HAZARDS

DURING THE MINUTE it will take you to read this page two American workmen will suffer eye injuries. Every thirty seconds thereafter another workman will clasp his hand, in pain, to one or both eyes, while fellow workers rush to his aid. At the end of an eight-hour day, today and every other work day, a thousand men and women in American factories, mills, mines, utilities, and other places of work will have suffered eye injuries. Some will have their eyes pierced by fragments of metal, wood, stone, or cinders; others will have the delicate tissues of their eyes ripped or crushed by larger flying objects; the eyes of still others will be burned by acids or caustics, by white-hot molten metal, or by the more subtle infra-red and ultra-violet rays of the welding torch; finally the eyes of some workers will go bad or stop working altogether because of the cumulative effect of the absorption of poisonous substances.

This goes on every working day with the result that some 300,000 eye injuries occur in American industries each year.[1] These injuries cost the employers more than $100,000,000 a year;[2] they cost the injured workmen and the communities in which they live an additional $100,000,000 yearly.[3] Most of this $200,000,000 annual loss and most of the human suffering resulting from these eye injuries—98 percent, in the opinion of those who

[1] See p. 19, below. [2] See p. 33, below. [3] See p. 36, below.

have made the most detailed study of the subject[4]—are wholly unnecessary. Of the 1,000 eye injuries which will occur today, all but 20 could be prevented.

There, in a nutshell, is the reason for a book on the eye hazards of industrial occupations. The inadequacies of available statistics make it impossible to say precisely what the eye hazards of industry cost in terms of blindness and defective vision. We do, however, have information about particular states, about certain large groupings of industries and other data developed by the United States Public Health Service and the United States Department of Labor, which together make possible some reasonable estimates.

On the basis of these estimates it may be conservatively stated that there are in the United States today more than 80,000 persons who have lost the sight of one eye as a result of industrial hazards and close to 8,000 who have lost permanently the sight of both eyes as a result of these accidents.[5] To this total there are probably added each year 1,000 or more who lose the sight of one eye and a hundred or more persons who lose the sight of both eyes as the result of occupational hazards.

In Pennsylvania, for example, the State Department of Labor and Industry reports that during the period of 1916 to 1936, inclusive, there was an average of 472 cases per year in which one eye was lost and an average of 30 cases per year in which both eyes were lost. In this one state 9,920 workers lost the sight of one eye and 628 workers lost the sight of both eyes during this twenty-one-year period. In New York State during 1931 to 1935, inclusive, an average of 12 workmen lost the sight of both eyes each

[4] See p. 27, below.

[5] In United States Public Health Service, "Blindness—Amount, Causes and Relation to Certain Social Factors," *National Health Survey*, 1935–36, the United States Public Health Service estimated the number of persons who had lost the sight of one eye to be 425,000, of whom 19.1 percent, or 81,175, lost the sight of an eye as the result of some occupational accident, and the number of persons totally blind to be 100,000, of whom 7.8 percent, or 7,800, were blinded as the result of occupational accidents. These estimates do not include the persons who have lost the sight of one or both eyes as the result of occupational diseases or the effects of industrial poisons.

year and some 2,000 workers suffered compensable eye injuries, most of which resulted in permanent partial loss of vision.

The number of men and women who have lost permanently part of the vision of one eye or of both eyes as the result of industrial accident or health hazards undoubtedly runs into hundreds of thousands, and this total is augmented each year by a number probably in excess of 10,000.

These are conservative estimates even if it is assumed that the records on which they are based represent a complete reporting of industrial eye injuries. We know, however, that the injuries reported are only part of the total number of eye injuries which actually occur. In many instances the injured worker does not know he is entitled to compensation, and no one enlightens him. Often the seriousness of an eye injury or the fact that it has or will result in permanent loss of vision does not become apparent until long after the injury has occurred, and in many such cases, for one reason or another, no official record of the accident is made. In still other cases the worker is more concerned about security of his job than in possible compensation for an injury, and so he does not press his claim for compensation. These are but a few of the many circumstances which account for failure to report eye injuries to the proper state authorities or to any other source which might lead to their inclusion in a compilation of the total picture of industrial eye injuries.

More serious than all the foregoing, among the factors contributing to the inadequacy of official records of eye injuries, is the rapidly spreading use in industry of poisonous chemicals and other deleterious materials which cause damage to the eyes. In many instances neither the workman whose eyes have been affected nor his physician knows that the worker has been exposed to poisonous fumes, liquids, or dusts. In many other cases damage to the eyes develops after the worker has left the employment of the company in which he, knowingly or unknowingly, worked with or near poisonous substances. In either event the true cause of blindness or of other serious damage to the eyes does not be-

come a matter of record in the state industrial commission or in any other source of data concerning industrial injuries or diseases.

In view of all this some of the most experienced safety engineers and labor law administrators are of the opinion that the total of eye injuries reported to the industrial commissions of the 48 states represents a 50 percent understatement of the real situation.

COST OF EYE INJURIES TO THE EMPLOYER

A recent analysis of the records of more than 4,000,000 industrial injuries representing the combined experience of at least half the casualty insurance companies of the United States during the years 1936 to 1939, inclusive, revealed, first, that 20 percent of all the accidents were compensable and, second, that these compensable accidents cost the employer or his insurance underwriter an average of $351 per injury for compensation and medical care. Applying these two findings to the estimate of 300,000 eye injuries per year, it develops that 60,000 of the eye injuries are compensable and that they cost the employers more than $20,000,000 a year for compensation and medical care.

These twenty million dollars represent just the beginning of the cost to the employer. H. W. Heinrich, of the Travelers Insurance Company, has pointed out that the hidden or indirect costs of industrial accidents are usually four times the cost of compensation and medical service.[6]

If we accept the ratio of hidden costs to direct costs as four-to-one, the total annual cost of compensable eye accidents assumes tremendous proportions: $20,000,000 for direct costs; $80,000,000 for indirect costs—a total of $100,000,000 paid each year by the employers of America for compensable eye injuries to their employees. All or most of this $100,000,000 of needless cost is ultimately paid by the consumer, the public at large.

Even the most trivial eye injuries—those involving no permanent damage to the eyes, no payment of workmen's compensation,

[6] Heinrich, *Industrial Accident Prevention,* pp. 18–19. See p. 31, below.

and little or no loss of time after the day of the injury—cost millions of dollars annually. After analyzing the experiences of its members with more than 4,000,000 industrial accidents, an association of casualty insurance companies found that the noncompensable accidents cost an average of $9.26 each for first-aid and medical care. On this basis the 240,000 noncompensable eye injuries which occur in American factories each year cost the employers $2,222,400 for first-aid and medical service. Applying the Heinrich formula (the indirect cost of accidents equals four times the direct or visible costs) we find that these so-called trivial accidents cost employers $10,000,000 a year.

Some further idea of the huge financial loss resulting to employers and employees from preventable eye injuries lies in the fact that eye injuries lead to the loss of more than 53,000,000 man-hours of work yearly.[7] This amounts to the full time of 26,880 men. In effect then, there are in the United States at any time 26,880 men and women who, though employed, are unable to work because of eye injuries. Exactly how much this enforced unemployment costs either the employers or the employees no one will ever know. When it is considered that among the workers most likely to receive eye injuries are machinists, tool makers, die and pattern workers, drill operators, lathe operators, and other skilled mechanics, most of whom are not easily replaceable, the seriousness of the loss to the employer becomes apparent. And when it is recalled that the compensation paid for industrial injuries is always a fraction of the regular salary of the individual injured, some idea is had of the dollar loss to these workers.

COST OF EYE INJURIES TO THE EMPLOYEES

Much publicity has been given in past years to the large sums industry can save by preventing accidents. Little progress has been made, however, in bringing to workmen a realization of what accidents cost them in lowered earning capacity and of the money saving they can make by doing their part in safeguarding

[7] See p. 30, below.

their eyes. Few workmen, for example, realize that the maximum compensation for total loss of vision of one eye is less than $2,000 in most states and as low as $1,000 in some.

The skilled shopworker who loses an eye in industry and receives $1,000 compensation—as he would in Oregon—is likely to lose that or more in the first year after the injury. He loses this in the difference between the wage he can earn with one good eye and the wage he would have been able to earn with two good eyes. The skilled workman living in the average American state which pays $2,000 for total loss of one eye loses that amount or more in the first two or three years after his injury, and thereafter his earnings steadily decline.

How many workmen would be willing to sell both of their eyes for $6,000 or less, the maximum compensation payable for loss of the sight of both eyes in a majority of states? Few workmen realize that at the very least they are risking a 33⅓ percent cut in salary for the rest of their lives every time they risk an eye injury. In the most liberal states the maximum compensation paid for total loss of vision is two-thirds of the wage received by the injured workman at the time of the accident. In some states the maximum compensation for total loss of sight is as low as $30 a month for life, as in Oregon.

COST OF INDUSTRIAL EYE INJURIES TO THE COMMUNITY

Over and above the heavy cost of eye injuries to industry and to the injured workmen themselves is the incalculable, but very large, cost to the community—the counties, cities, states, and the nation—of having in its midst an ever-increasing number of blind and partially blind men and women who, until their sight was impaired or destroyed, were for the most part, efficient industrial workers, self-supporting and usually the chief or sole support of a family. Some notion of the magnitude of this cost may be had from the fact that in 1940 the Federal and state Social Security agencies spent more than $13,000,000 for aid to 48,000 needy blind persons, many of whom lost their sight in occupational pur-

suits. At the same time, other relief agencies spent millions more to aid families whose breadwinners were unemployed or whose earning capacity had been greatly reduced in either case because of total or partial blindness resulting from some occupational eye hazard.

Such huge round figures as $200,000,000, representing the cost of eye injuries, are so far beyond the everyday affairs of most of us they do not present as realistic a picture of the seriousness of the situation as may be had from the smaller, more specific figures of one day's eye injuries.

THE EYE INJURIES OF ANY ONE DAY

Of the 1,000 workers whose eyes will be injured today, 200 will be so seriously injured as to be entitled to compensation. This compensation and the cost of medical care will average $351 per injury, or a total of $70,200 for the day. In most of these cases the injury will result in some permanent loss of vision; in some—no one can tell how many—today's eye injuries may result in total blindness of one eye or of both eyes. Each case of total loss of vision of one eye resulting from today's injuries will add $1,000 to $5,000 to the compensation costs, depending on the states in which the accidents occur. Each case of total blindness of both eyes which may result from today's accidents will add between $6,000 and $30,000 or more to the day's compensation costs. Then there are the 800 minor, or noncompensable, eye injuries on this one day; these will cost an average of $9.26 each for medical care, or $7,408 for the day.

Taking the most optimistic view and assuming that none of today's accidents result in total loss of vision of one eye or of both eyes, we are nevertheless confronted with a direct cost (for compensation and medical care) of $77,608 to the employers as a result of today's eye injuries. The indirect costs of these injuries are four times as great, and so the total cost to the employers is $378,040. At the same time, if today's eye injuries are typical, the 1,000 workmen will suffer permanent total or permanent partial loss of vision which eventually will cost them and the communi-

ties in which they live a sum equal to the employers' losses. This will bring the grand total of financial loss resulting from today's eye injuries to more than $750,000.

THE PROFIT MOTIVE IN SAFETY

The reader may well wonder about this emphasis on the monetary cost of industrial eye injuries. The reason for this emphasis is to be found in a statement by E. R. Granniss, director of the Industrial Engineering Division of the National Conservation Bureau:

> The most notable advances in the safety movement have been made, not through humanitarian agitation, but by producing factual data to show that accidents involved important expenditures and that it was far cheaper to pay for accident prevention than to have to pay the costs of accidents. Unfortunately, every employer is not yet convinced of the economic advantage of a safety program.[8]

Some progress in the industrial safety movement and in other comparable campaigns can be directly traced to "humanitarian agitation." Thus, the picture of a blind child and the caption "This Child Need Never Have Been Blind" in the report of a state commission to investigate the condition of the blind so stirred the emotions of Louisa Lee Schuyler that the movement for the prevention of blindness was organized thirty-three years ago.

No amount of descriptive or imaginative writing can describe what really happens to the workman who has been blinded by an accident, an occupational disease, or exposure to poisons which gradually or suddenly cut off his power to see. The blind do not like to be pitied or to be spoken of as "the handicapped." Many men, women, and even children deprived of sight have nevertheless developed into happy, self-supporting, and efficient citizens. This should not, however, obscure the fact that when suddenly robbed of the faculty of seeing an adult workman, more often than not in the prime of life, is confronted with one of the most

[8] In an address before the convention of the Greater New York Safety Council, New York City, March 27, 1939.

bitter tragedies possible. There is stark tragedy merely in the inability to see loved ones, customary daily surroundings, and all the little or big things which have given particular pleasure. To this there is added in the case of most workmen blinded by occupational hazards the further tragedy of being suddenly deprived of the ability to work and to earn a livelihood for himself and his family. It is true that American states are more liberal than those of any other land in monetary compensation to workmen who have lost all or part of their sight in industry, but even in the most liberal of our states this compensation does not begin to equal the normal earning capacity of the individual prior to the injury to his eyes.

We know that the sight conservation program, and in some cases the entire safety program, of particular plants have been inspired by humanitarian motives. No one familiar with the industrial safety movement will, however, seriously dispute the statement that realization of the high cost of accidents and of the great money savings possible through their prevention has been—and is today—the most effective force for accident prevention and health promotion within industry. The principal difficulty has been that of bringing this realization to busy and often skeptical business executives, more particularly to the plant managers, superintendents, foremen and other subexecutives to whom they delegate responsibility for plant management.

Irrespective of whether the impelling motive has been monetary or humanitarian, the fact remains that in the 15-year interval since the publication of the earlier edition of this handbook, great progress has been made by American industry in protecting the eyes of its workers.

ADVANCES IN ELIMINATION OF EYE HAZARDS

First among the many indications that progress has been made in eyesight conservation in industry during the past 15 years is the fact that there are in the industries of America today far fewer amateur "shop oculists"—the kind who use toothpicks, matches, pocket knives, files, screwdrivers, and other infection-

bearing instruments to remove particles from the eyes of injured fellow workers. The tremendous damage done to eyes of industrial workers in the past by crude and bungling first-aid can hardly be overemphasized.

There are fewer of these amateur "shop oculists" because of the greater appreciation by workmen and by management of the importance of avoiding infection even in the most minor eye injury and because there are now far more well-equipped first-aid rooms, with doctors or nurses in charge, in industrial properties than there were fifteen years ago. The *American Medical Directory* now records 345 physicians who are limiting their work to industrial medicine, and 1,000 others who report industrial practice as their special interest.

That there is still far to go in this respect is indicated by the fact that the bulk of medical service to men and women injured in industry is rendered by general practitioners, many of whom have little knowledge of conditions in industry which lead to the injuries or industrial diseases they are called upon to treat. This lack of information about the industrial conditions often handicaps the doctor in diagnosing or treating an industrial patient and certainly limits his ability to tell the patient or his employer how best to protect the worker's health on his return to employment. There is great need for bringing to general practitioners of medicine throughout the country, particularly in industrial areas, more information about the accident and health hazards of industry. This, the National Society for the Prevention of Blindness is endeavoring to do with respect to those accident and disease hazards which affect the eyes.

Progress has been made in eliminating accident and disease hazards which affect the eyes by increased use of ventilation, exhaust systems, and air conditioning. Use of exhaust systems to remove poisonous gases and dangerous dusts has saved thousands of workmen from daily exposure to working conditions which eventually, and often suddenly, result in seriously impaired vision, if not total blindness. Ventilation, air-conditioning, and exhaust systems installed for this purpose more than pay for them-

selves through the increased efficiency of the workers they protect, to say nothing of lowered workmen's compensation costs.

Substantial progress has been made in the provision of proper industrial lighting which, like ventilation, has both increased the efficiency of employees and conserved their sight. While it may not be possible to point to particular individuals who have become blind through working under poor lighting conditions, there is substantial evidence of the direct relation between bad lighting and bad eyesight. One striking bit of such evidence is the report of a study made by the United States Public Health Service of the relation of good lighting to occupational efficiency in two New York City post offices, details of which will be found in Chapter VIII.

In the field of ophthalmology great strides have been made in the treatment of eye injuries and diseases. For example: the edition of *Eye Hazards in Industrial Occupations* which appeared fifteen years ago opened with the statement: "No one has yet produced an artificial eye that can see; nor does anyone dare predict the day will ever come when it will be possible to replace the human eye with an artificial eye that will see." This is still true, but something almost as miraculous as an artificial eye that can see has happened during the intervening fifteen years. That something has been mistakenly referred to in newspaper and magazine articles as "the transplanting of human eyes." Successful transplantation of a whole eye has never been accomplished. What actually has happened has been the transplanting of small segments of eye tissue—an operation which has restored considerable sight to some who had little vision left and has saved others from impending blindness. More than 100 such operations have been performed in one New York hospital, many with good results.

Less spectacular, but even more effective, procedures for saving the eyes of workmen after slivers of steel have pierced their eyes have been developed, and treatment of industrial eye injuries of various sorts has been greatly improved in the past decade or two.

The discovery and the correction of defective vision among em-

ployees also have seen great progress in American industry. More plants have pre-employment examinations and follow-up eye examinations; the quality of eye examinations in industry has greatly improved. Plants once content to have an employment clerk test vision by a chart and end the eye examination there, now recognize the desirability of having an oculist examine the eyes of every worker before he is put on the pay roll and periodically thereafter.

Despite all the progress in this direction there is still the need of reminding the managers of many industries that poor vision—whether due to insufficient light or to uncorrected eye defects—is one of the principal causes of fatigue, not of the eyes only, but of the entire body. Frank Gilbreth, one of the earliest authorities on fatigue in industry, said: "No fatigue is more wearing than eye fatigue." Today the situation in many plants—with respect to both lighting and the visual acuity of workers—indicates that the managers of these plants are still either unaware of this or are unconcerned about it, despite the fact that it costs them very substantial sums.

Marked progress has been made in the education of workers and management as to the wearing of goggles. Fifteen years ago few employers were willing even to ask workers such as carpenters and painters to wear goggles. Today, in a number of companies where almost every trade and craft is represented, every employee, every foreman and superintendent, and every visitor is required to wear and does wear goggles all the time they are in the plant. While there is far more widespread and more consistent wearing of goggles than ever before, the progress made in this direction is still merely a beginning. If every industrial plant did require all employees and visitors to wear goggles, millions of dollars now paid as compensation for eye injuries in American industries each year would be saved; scores of workers would be saved from blindness each year; and thousands more would be saved from serious eye injuries which, while not producing blindness, leave them with vision in one eye only or with limited vision in both eyes.

Great progress has been made in training factory inspectors—both insurance and state government inspectors. Fifteen years ago it was a commonly voiced opinion that the average safety inspector, whether he worked for a state department or an insurance company, could have little influence with management except through his reporting of safety code violations, and even that part of his work was done by rote. Today more and more safety inspectors are genuine experts in the detection and the control or elimination of accident and health hazards in industry. The United States Department of Labor has assumed leadership in the training of state safety inspectors, and the insurance companies have done much to make their inspectors safety engineers rather than mere field clerks or reporters. The importance of all this lies in the fact that in the last analysis the battle for safety is carried on by the safety inspector. In thousands of plants too small or too backward to employ a safety engineer it is the safety inspector—whether he be a state inspector or an insurance inspector—who has the opportunity to put vitality into the safety program or to allow it to lapse into a mere paper program.

SOME REMAINING PROBLEMS

Much has been accomplished, but much more remains to be done. At this late date, after 25 years of safety campaigns, there is still to be found in some plants a pair of goggles on a nail beside the grinding wheel for the use of all men who may have occasion to work at the wheel. The tremendous progress that has been made in the design, manufacture, and promotion of goggles and in education as to their use makes the lone pair of dust-accumulating goggles on a nail or in a cigar box over the emery wheel for common use an inexcusable, obsolete, and wasteful gesture toward eye protection.

Almost as much can be said for towels used in common, even greater carriers of eye disease than the goggles. The old-fashioned roller towel was long ago legislated out of existence, and general sanitary conditions in most work places have been greatly improved. But there still are hundreds of thousands of industrial

workers for whom no clean wash rooms and no clean towels are available. So long as such conditions exist, workers are exposed to diseases which may seriously affect their sight—and their employers' compensation costs.

There is another most important hazard to sight concerning which it is not clear whether the past fifteen years have seen progress or retrogression. Fifteen years ago the second edition of *Eye Hazards in Industrial Occupations* listed 22 industrial poisons, the use of which presented hazards to the eyes. The present edition lists more than 90 industrial poisons involving hazards to the eyes. Whether this represents progress in the recognition of the dangers involved in the handling of poisons or merely the introduction of new poisons injurious to the eyes is not clear; it probably represents both.

Of this we can be sure: the growing use of poisonous chemicals in industry presents one of the most serious hazards to the eyes of workers. This hazard is aggravated by the fact that thousands of men and women who are working with these poisons are unaware of that fact, unaware of the disease hazards to which they are exposed, and unaware of the steps they should take to guard against the harmful effects of these poisons. This is so because in many plants the poisonous chemical mixtures are trade secrets known to most of the persons who handle them only by some such symbol as "Solution B3" or "Solution C4," the precise make-up of the solution being known to only a few persons in the plant.

As industry comes to be held responsible for the effects of these poisons through their designation as compensable occupational disease hazards, progressive employers will use every known means to protect the workers exposed to these poisons. Meanwhile, it is the responsibility of every safety engineer, of every physician or surgeon having any industrial practice, and of every industrial nurse to become familiar with all the poisonous substances used in their respective plants and to take all possible steps to protect the employees exposed to these poisons.

CONCLUSION

Conditions observed during the past twenty years in American factories, mines, mills, railroads, and other work places leads inevitably to the conviction that accidents are not inherent in industry, that they are almost 100 percent preventable, that the dividends on investments in accident prevention may be proportionately greater than the dividends on the primary business of an industry. There is no need for the blinding of any worker in American industry. The industrial accident and disease hazards affecting the eyes are now commonly known; methods of eliminating these hazards or of protecting workers against them have been thoroughly demonstrated; devices which provide protection against almost every type of eye accident are now available.

Practically all the financial loss and the human suffering resulting from the blinding of industrial workers, could be averted by coöperation of employers and employees in the utilization of demonstrated methods of preventing accidents and diseases. Not only would these losses be averted but also the efficiency and the earnings of both employees and employers would be substantially increased if all industry did what is being done successfully in a few plants in America to prevent eye injuries.

The obligation to put into effect the methods, devices and practices which experience has demonstrated to be successful in protecting the eyes of workers belongs to many groups. It is an obligation first of all on the owners and managers of industry and on all their executives and sub-executives. It is a responsibility of employees individually and collectively through their labor union and other organizations concerned with the health and welfare of workers. It is an obligation of government administrators—Federal, state, municipal, and county alike. It is an obligation of public and private health and welfare agencies which have any contact either with industry or with industrial workers. It is most directly the responsibility of safety engineers, safety inspectors, industrial physicians, ophthalmologists, general physicians, surgeons, nurses, and local sight conservation agencies.

Chapter II

THE PROBLEM OF EYE ACCIDENTS

ANY STUDY of the means of eliminating eye hazards from industrial occupations or of counteracting their effect would be helped by knowing when, where, how, why, and to what extent eye injuries occur as a result of these hazards. Relatively little authentic statistical information is to be found on these subjects, and what is available is fragmentary and so little standardized that worth while comparisons are impossible in many instances.

While a majority of states have industrial commissions charged with the responsibility of recording at least compensable industrial injuries, most of these commissions report they are so handicapped by lack of funds and staff as to be unable to analyze or publish such statistics while they still have any timeliness. In little more than half a dozen states is it possible to secure statistics of eye injuries according to nature, causes, and costs for recent years.

The situation within individual industrial plants is even worse. After 25 years of effort by the various safety organizations, governmental departments, and public-health agencies to secure some form of standardization in record keeping, there is still an endless variety of interpretation within individual properties as to what constitutes a serious injury and what constitutes a lost-time injury and as to methods of recording the accidents of the plant. Some of the largest industrial corporations of America do not even analyze injuries by causes within their own properties.

Despite the limited and incomplete statistics available, some

helpful estimates can be made of the number, extent, nature, causes, and cost of industrial eye accidents in the United States.

THE NUMBER OF EYE ACCIDENTS OCCURRING ANNUALLY IN THE UNITED STATES

Dr. Louis Schwartz, of the United States Public Health Service, estimated in 1932 that 300,000 industrial eye accidents necessitating a layoff from work of one day or more occur each year in the United States. More recent data indicate there has been little change in this respect. The industrial commissions of Indiana, Kentucky, Massachusetts, Minnesota, Ohio, and South Dakota—the only states recording all eye injuries—reported 50,963 eye injuries in one recent year. These six states are fairly representative with respect to geographic location, urban and rural areas, industrial and agricultural distribution, and they represent 16.2 percent, or nearly one-sixth of the national population. If we regard the 50,963 eye accidents reported by these six states as 16.2 percent of the total number of eye accidents occurring annually, the total for the United States would be 315,000, a figure at slight variance to that arrived at by Dr. Schwartz on an entirely different basis.

The closest approach to a statistical picture of the extent of eye injuries in industry, nationally, may be had from the data reported to the United States Department of Labor by 23 of the states and summarized in Table 1:

It should be noted that some states classify only permanent injuries, others only compensable cases, still others only those of certain particular industries or causes, and that there is a variance of five years in the statistics reported by the various states as their most recent analysis of eye injuries.

The fact that Ohio reports more accidents than all other states combined does not indicate a proportionately higher accident rate, but merely that Ohio reports all accidents necessitating a layoff of one day or more. Illinois, New York, and Pennsylvania—states having larger populations than Ohio—all report considerably fewer accidents than Ohio because only compensable cases

TABLE 1

EYE INJURIES REPORTED BY STATE INDUSTRIAL COMMISSIONS

State	*Year*	*Cases Reported*	*Percentage of All Injuries*
Georgia	1933	44[a]	6.5
Idaho	1936	863[b]	10.0
Indiana	1934	1,229	7.0
Illinois	1937	1,064[b]	2.5
Iowa	1936	203[c]	5.0
Kansas	1937	352[d]	3.5
Kentucky	1936	788	7.0
Maryland	1937	387[b]	3.0
Massachusetts	1937	1,184	3.0
Michigan	1933	2,205[b]	16.7
Minnesota	1936	2,374	8.7
Missouri	1932	1,474[b]	6.3
New York	1935	1,618[b]	2.3
Ohio	1937	44,876	18.8
Oklahoma	1934	268[b]	5.4
Pennsylvania	1936	320[a]	10.3
Rhode Island	1935	49[b]	2.1
South Dakota	1935	512	11.4
Utah	1938	19[a]	5.9
Vermont	1936	16[a]	8.3
Washington	1936	648[b]	3.4
West Virginia	1936	98[a]	8.0
Wisconsin	1937	992[b]	4.0

[a] Permanent injuries only.
[b] Compensable injuries only.
[c] Coal-mine and railway train service accidents not included.
[d] Injuries caused by foreign matter in the eye only.

are recorded by the commissions of these states. Table 1 indicates, if nothing more, the need for greater uniformity in the recording of accident statistics by the various state industrial commissions.

These reports from the industrial commissions of approximately half the states are chiefly valuable for the light they throw on the relation of eye injuries to all injuries. It will be noted that this ratio varies from a low of 2.1 percent, in Rhode Island, to a high of 18.8 percent in Ohio. Michigan, another heavy-industry state, reports that compensable eye injuries constitute 16.7 per-

cent of all compensable injuries. Pennsylvania, reporting only those accidents which result in permanent disability, finds that eye injuries constitute 10.3 percent of all such accidents. These are considerably higher percentages than have been generally assumed to represent the ratio of eye injuries to all injuries. They appear all the more significant in the light of a comparison of

Table 2

CLASSIFICATION OF 58,387 EYE ACCIDENTS BY INDUSTRY[a] IN ONE RECENT YEAR

Industry	*Illinois*	*Kansas*	*Michigan*	*Missouri*	*Ohio*	*Tennessee*	*Utah*	*Total*
Agriculture	11		12	20	70		1	114
Automobile manufacturing, repairing, and garaging	42		188	38		39	2	309
Building and general construction	225	42	120	139	3,071	83	2	3,682
Clerical and professional service	10	3	9	41	206	4		273
Food products manufacturing	62	15	164	57	554	16	1	869
Metal and metal products manufacturing	568	39	609	396	33,477	96	2	35,187
Lumber and wood products manufacturing	42	8	196	11	1,400	66	1	1,724
Mining and quarrying	490	17	77	46	1,088	82	9	1,809
Paper manufacturing	20		72	17	795	6		910
Public utilities	39	25	19	38	337	3		461
Smelting and refining; oil and gas products	4	35		6		12		57
Stone, clay, and glass manufacturing	29		7	23	1,911	17		1,987
Textiles, leather, and laundry	24	2	41	34	644	39		784
Trade and finance	98	13	320	68	2,723	10		3,232
Transportation	68	4	40	90	2,423	25		2,650
All others	135		131	390	3,662	21		4,339
Total	1,867	203	2,005	1,414	52,361	519	18	58,387

[a] From data reported to the Bureau of Labor Statistics, United States Department of Labor, by the various state industrial commissions.

the medical and compensation costs of eye injuries with the costs of all injuries, which is presented later in this chapter.

WHERE DO EYE ACCIDENTS OCCUR?

Analysis of 58,387 eye accidents occurring during one recent year in the seven states that reported accidents by industry—Illinois, Kansas, Michigan, Missouri, Ohio, Tennessee, and Utah (see Table 2) shows that 35,187, or 60 percent, occur in metal and metal-products manufacturing industries. In six of these seven states metal and metal-products manufacturing was responsible for the largest number of eye accidents. Building and general-construction industries were responsible for the largest number of eye accidents in one state and the second largest number in four states. Lumber and wood-products manufacturing, mining, and quarrying also accounted for large numbers of eye accidents.

Such supposedly nonhazardous occupations as clerical and professional service accounted for 273 eye injuries in one year in these seven states, while trade and finance, also among pursuits considered nonhazardous, at least so far as eye injuries are concerned, are credited with 3,232 such injuries in one year in these seven states.

Further light on where eye injuries occur and on their relation to all injuries is cast by an analysis of eye accidents in seventeen industrial plants in and near Newark, N.J., made by Dr. Elbert S. Sherman, Surgeon of the Newark Eye and Ear Infirmary. The chart which follows represents the accident experience of these seventeen plants during 1934–1936.

The extraordinarily high ratio of eye accidents to all accidents shown in Table 3 undoubtedly reflects the wisdom of regarding any eye injury, no matter how slight, as serious enough to warrant the attention of a doctor. As is to be expected, the three highest ratios of eye injuries to all injuries—52.3 percent, 42.8 percent, and 42 percent—represent machine shops and machine-tool plants. In fact, all those plants having abnormally high percentages of eye accidents, with two exceptions, were in the metal and metal-products manufacturing industries. The two exceptions were a

TABLE 3

RATIO OF EYE ACCIDENTS TO ALL ACCIDENTS IN SEVENTEEN PLANTS IN THE NEWARK, (N.J.) INDUSTRIAL AREA

Kind of Industry	*Number of Employees*	*Number of Years*	*Total Accidents*	*Eye Accidents*	*Percentage of Eye Accidents as Related to Total Accidents*
Tank manufacturing .	200	2	163	38	23.3
Machine tools	300	2½	248	105	42.0
Rolling mill	100	2½	48	6	12.5
Foundry	200	2	145	44	30.3
Textile printing . . .	200	2½	211	12	5.6
Bakery	50	2½	58	2	3.4
Plastic molding . . .	125	2	45	6	13.3
Woodworking	400	2	121	16	13.2
Machine shop operations	3,000	1	1,651	864	52.3
Machine shop and boiler works	700	2	252	55	21.8
Machine shop operations	300	2	166	43	26.0
Machine shop	100	2	45	9	20.0
Metal goods	25	3	14	4	28.5
Metal goods	20	2	14	2	14.2
Machine shop	10	1½	7	3	42.8
Printing	25	1½	8	0	0
Radio manufacturing	40	2⅙	19	1	5.2
Totals	5,795		3,215	1,210	37.6

plastic molding plant (13.3 percent) and a woodworking plant (13.2 percent). It is significant that size of plant apparently does not influence the ratio of eye accidents to all accidents. Of the three plants having the highest percentages of eye injuries, one employed 10 men, one employed 300 men, and one employed 3,000 men. Neither Table 2 nor Table 3, however, can be regarded as an accurate representation on a national basis of the ratio of eye injuries to all injuries in different industries; both tables are heavily weighted by the preponderance of certain industries in particular states. In Table 2, for example, Michigan

is shown to have more eye accidents in the automotive industries than do the six other states combined. This is so simply because these industries are centered in Michigan. Pennsylvania has a disproportionately large number of eye injuries in mining and metals industries because of the preponderance of steel and mining operations in that state. While no accurate statement can be made as to the ratio of eye injuries to all injuries in specific industries for the country as a whole, it is evident that the most hazardous industries, so far as eyes are concerned, are metal and metal-products manufacturing, mining and quarrying, building and general construction, lumber and wood-products manufacturing.

Just what specific operations make these industries so hazardous to the eyes? The answer can be found in part in the tabulation of 3,571 eye accidents which occurred during one recent year in Minnesota and Illinois (see Table 4). More than 50 percent of these accidents were caused by flying particles set in motion by hand tools, machinery, and various unclassified sources. The next most common causes were abrasive wheels, corrosive substances, electric flashes, and molten metal. It is significant that all these—the most hazardous operations—are to be found in metal and metal-products manufacturing—the most hazardous industry. Flying particles—chips of steel, iron, brass, and copper—set in motion by chisels, pneumatic hammers, mechanical drills, hand files, and the like cause more than one out of every two eye accidents in industry.

From the Drop Forging Association, an individual trade association, comes confirmation of the fact that a large number of eye injuries occur in that branch of the metal-working industry and that these injuries are caused principally by flying particles.

The Drop Forging Association, analyzing the accident experience of 47 of its member plants during 1940, reports a total of 2,234 lost-time and minor accidents, of which 746, or 33 percent, were eye accidents. Of these 746 eye accidents, 696, or 93 percent, were caused by chips, scales, dust or dirt, and only 7 percent by all other causes combined.

Table 4

ANALYSIS OF 3,571 EYE ACCIDENTS OCCURRING IN MINNESOTA AND ILLINOIS IN ONE RECENT YEAR[a]

CAUSE OF ACCIDENT	NUMBER OF CASES *Illinois*	*Minnesota*	*Total*
Flying particles (not classified)	163	1,267	1,430
Flying particles set in motion by hand tools	185	789	974
Abrasive wheels	17	239	256
Corrosive substances	30	88	118
Molten metal	Not reported	36	36
Acids	13	35	48
Electric flash, including welding	Not reported	51	51
Flying particles set in motion by machinery	Not reported	47	47
Stripping of hand tools	4	22	26
Hot substances	25	26	51
Falling objects	28	18	46
Flames	11	9	20
Striking against objects	19	17	36
Handling sharp objects	16	8	24
Falls of persons	7	4	11
Blasting and explosions	13	6	19
Lime and cement	25	24	49
All others	268	56	324
Grand total	824	2,742	3,566

[a] Based on data provided by the industrial commissions of Illinois and Minnesota.

ACCIDENT CAUSES—ANALYSIS

The classification of eye-accident causes used by the industrial commissions of Illinois and Minnesota is, with minor variations, the commonly accepted classification of eye-accident causes. These are, however, merely the immediate or surface causes, not the underlying or fundamental causes. Flying particles, abrasive wheels, corrosive substances are not the real *causes* of accidents; they are the agents or the means by which accidents occur. More often the true cause of an accident and of the resultant eye injury is faulty instruction by a foreman or disobedience of rules by an employee

leading in turn to such unsafe practices as exposure to flying particles, improper installation or use of an abrasive wheel, and so forth. Chart I and the accompanying explanatory notes offer a picture of the fundamental causes of accidents as seen by H. W. Heinrich, of the Travelers Insurance Company, after studying detailed records of many thousands of accidents. Mr. Heinrich discusses at length what he describes as "true cause-analysis of accidents." This analysis of the true causes of industrial accidents is based on a study of detailed reports of accidents occurring over a period of 17 years. Chart I is reproduced through the courtesy of the McGraw-Hill Book Company, Inc., publishers of *Industrial Accident Prevention,* by H. W. Heinrich, Assistant Superintendent of the Engineering and Inspection Division of the Travelers Insurance Company, and originator of the chart.

Explaining his industrial-accident-cause analysis chart, Mr. Heinrich says:[1]

1. Both supervisory and physical causes may be controlled by the employer. It is apparent that in the last analysis the employee also may avoid accidents, even though he is exposed to unsafe conditions.
2. Accidents due to mechanical or physical exposures should be assigned to causes in the supervisory group, where the foreman had authority to install or maintain guards. In such cases the chief cause is laxity in supervision. This line of reasoning produced the total of 10 percent shown in the "physical" group. As ordinarily analyzed, the physical total is 25 percent.
3. The value of analysis by the causes listed in the chart, as compared to the existing method of allocation as slips and falls, eye injuries, and others, is apparent. It permits concentration upon the things that count. It directs attention to supervisory responsibility or to physical hazards, both of which are controllable.
4. Supervisory item 2, refers to *chronic* poor judgment, ignorance, and lack of skill, since *temporary* inability in these respects sometimes applies to properly qualified employees and would therefore be more likely to come under items 3, 4, or 5.
5. Terms such as "carelessness," "poor supervision," and "improper selection of employees," have deliberately been omitted because of ambiguity.

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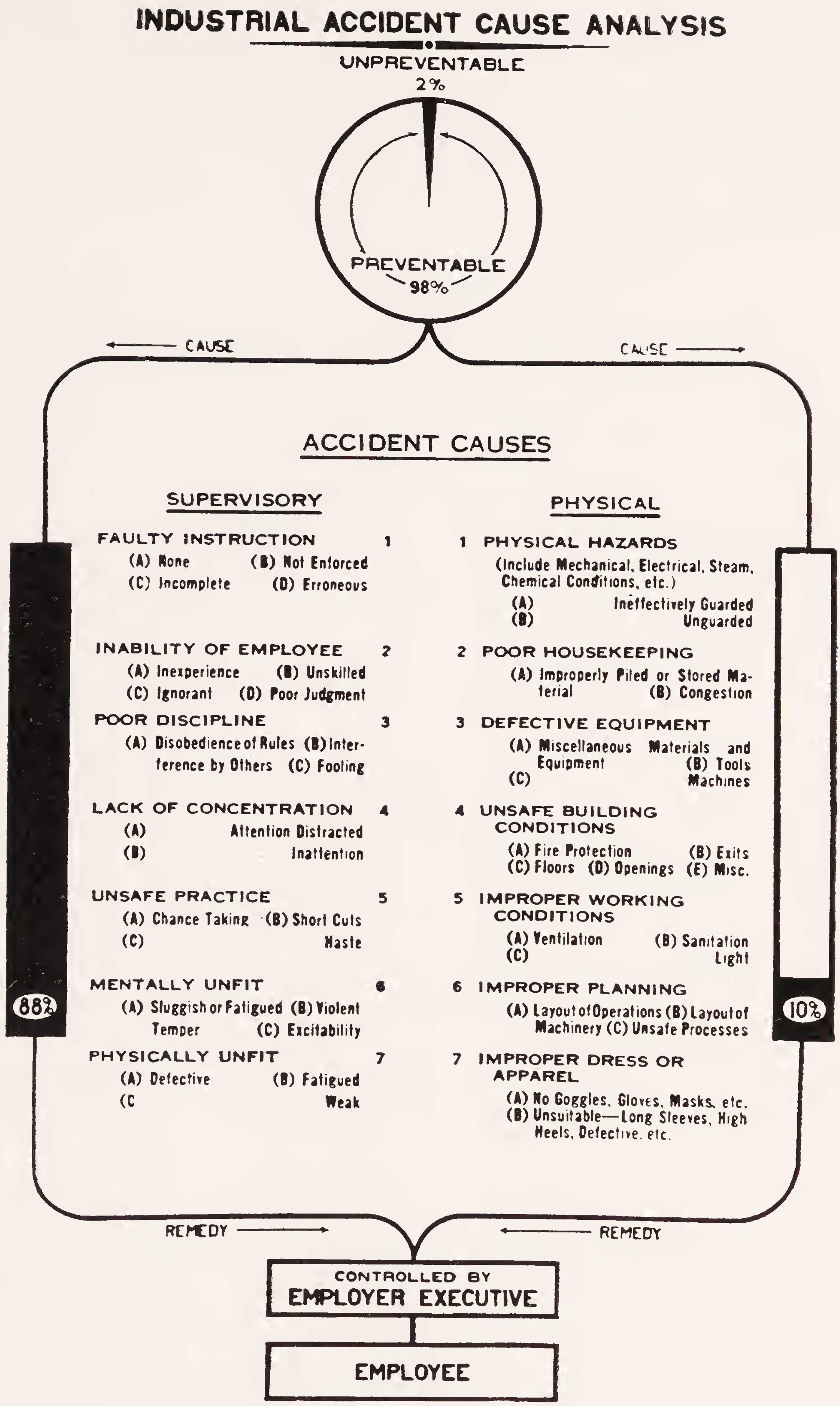
[1] Heinrich, *Industrial Accident Prevention,* p. 47.

CHART I


INDUSTRIAL ACCIDENT CAUSE ANALYSIS
UNPREVENTABLE
2%
PREVENTABLE
98%
CAUSE
CAUSE
ACCIDENT CAUSES
SUPERVISORY
FAULTY INSTRUCTION 1
(A) None (B) Not Enforced
(C) Incomplete (D) Erroneous
INABILITY OF EMPLOYEE 2
(A) Inexperience (B) Unskilled
(C) Ignorant (D) Poor Judgment
POOR DISCIPLINE 3
(A) Disobedience of Rules (B) Interference by Others (C) Fooling
LACK OF CONCENTRATION 4
(A) Attention Distracted
(B) Inattention
UNSAFE PRACTICE 5
(A) Chance Taking (B) Short Cuts
(C) Haste
MENTALLY UNFIT 6
(A) Sluggish or Fatigued (B) Violent Temper (C) Excitability
PHYSICALLY UNFIT 7
(A) Defective (B) Fatigued
(C Weak
88%
PHYSICAL
1 PHYSICAL HAZARDS
(Include Mechanical, Electrical, Steam, Chemical Conditions, etc.)
(A) Ineffectively Guarded
(B) Unguarded
2 POOR HOUSEKEEPING
(A) Improperly Piled or Stored Material (B) Congestion
3 DEFECTIVE EQUIPMENT
(A) Miscellaneous Materials and Equipment (B) Tools
(C) Machines
4 UNSAFE BUILDING CONDITIONS
(A) Fire Protection (B) Exits
(C) Floors (D) Openings (E) Misc.
5 IMPROPER WORKING CONDITIONS
(A) Ventilation (B) Sanitation
(C) Light
6 IMPROPER PLANNING
(A) Layout of Operations (B) Layout of Machinery (C) Unsafe Processes
7 IMPROPER DRESS OR APPAREL
(A) No Goggles, Gloves, Masks, etc.
(B) Unsuitable—Long Sleeves, High Heels, Defective, etc.
10%
REMEDY
REMEDY
CONTROLLED BY
EMPLOYER EXECUTIVE
EMPLOYEE

6. An unpreventable accident (one of the 2 percent group) may actually be due to one of the causes listed in the chart, yet the circumstances may prohibit assignment as a preventable case.

7. Some of the causes appear to overlap (unskilled and ignorant, for example), yet there are occasions when an accident is clearly chargeable to only one of the items, consequently all causes have been included in the foregoing list. Contributory causes should be shown as of secondary importance.

Although Heinrich's principles of accident-cause analysis have been generally accepted in discussions of accident causes, they have not yet affected, to any appreciable extent, methods of tabulating accident statistics. Some few plants are making an effort to discover the underlying rather than the superficial cause of each accident. It is apparent that industry generally is not yet willing to dig as deeply into the causes of accidents as is necessary under the Heinrich principle of cause analysis. Until industry is willing to set up the investigating machinery necessary to ascertain the true causes of accidents, it will not succeed in eliminating accidents to the degree to which this is possible.

THE MOST COMMON TYPES OF EYE INJURY

More is known about the nature of eye injuries than about their causation. The most common types of eye injury are the presence of foreign bodies in the eye, lacerations and punctures, burns and scalds, and bruises and contusions. When an analysis was recently made of more than 4,000,000 compensable and non-compensable cases which represented the combined experience of at least half the casualty insurance companies of the United States during the years 1936 to 1939, inclusive, 90 percent of the eye cases were of the four types of injury mentioned above. (See Table 5.)

COST OF EYE INJURIES TO THE EMPLOYER

Eye injuries cost the employers of this country nearly $2,500,000 in compensation and medical costs each year. These eye accidents, representing only three percent of the total number of compensable accidents, cost the employers six percent of the total

Table 5

COMPARISON OF EYE ACCIDENTS WITH ALL ACCIDENTS—NUMBER, COMPENSATION, MEDICAL COST, AND PERIOD OF DISABILITY

Type of Injury		*Number of Cases*	*Compensation (Average)*	*Medical Cost (Average)*	*Temporary Disability (Days)*	*Permanent Disability (Weeks)*
Cuts, lacerations, punctures, abrasions	Total	202,728	$ 79	$ 42	28	3
	Eye	5,266	313	90	45	20
Bruises and contusions	Total	154,345	85	45	34	2
	Eye	1,841	199	65	33	12
Foreign bodies	Total	24,265	142	61	34	7
	Eye	12,762	198	69	36	10
Burns and scalds	Total	40,040	102	65	36	3
	Eye	2,709	210	79	47	9
Fractures	Total	137,325	287	114	81	11
	Eye	74	306	114	45	17
Sprains or strains	Total	147,948	106	47	42	2
	Eye	58	137	73	32	4
Dislocations	Total	7,822	218	90	68	9
	Eye	17	813	248	187	31
Amputations or enucleations	Total	24,091	549	112	75	34
	Eye	409	1,939	292	122	138
Tendon or nerve injuries	Total	6,318	271	102	66	12
	Eye	52	550	183	97	38
Not classified	Total	15,872	179	73	57	5
	Eye	997	548	131	109	24
Diseases	Total	59,574	179	114	62	5
	Eye	(Undetermined)				
Grand totals and averages	Total	820,328	$149	$66	46	5
	Eye[a]	24,185	$270	$81	37	15

[a] Exclusive of undetermined number of eye cases caused by disease.

compensation, indicating that eye injuries are far more costly than other injuries. For example, the average compensation for cuts, lacerations, and punctures of the eye—among the most common types of eye injury—is four times as great as the average compensation for cuts, lacerations, and punctures of the rest of the body. Average compensation for bruises and contusions of the

eye—another common type of injury—is nearly three times as great as the average compensation for all cases of bruises and contusions.

As in compensation, eye injuries are far more expensive than injuries to other parts of the body in terms of disability. The average permanent (partial) disability for all cases was 5 weeks, whereas the average permanent (partial) disability resulting from eye injuries was 15 weeks—three times as great as for all injuries. In general the average compensable eye injury costs the employer or his insurance underwriter $270 for compensation, $81 for medical expenses, 37 days in temporary disability and 15 weeks in permanent disability.

Of 4,333,124 injuries, 820,328 or nearly 20 percent, were compensable. If we apply this percentage to the estimate of 300,000 eye injuries occurring annually in the United States, the total cost to industry for 60,000 compensable eye cases (20 percent of 300,000) is $16,200,000 in compensation and $4,860,000 in medical costs or more than $20,000,000 per year. Accepting the forty-hour week as a standard, the time lost each year as a result of temporary and permanent disability for 60,000 compensable eye injuries is 17,760,000 man-hours because of temporary disability and 36,000,000 man-hours as a result of permanent disability, a total of 53,760,000 man-hours lost each year to industry. Translating man-hours into man-years on the basis of 50 working weeks of forty hours each or 2,000 hours in each year, the number of man-years lost annually as a result of compensable eye injuries is 26,880. Every year American industry loses $20,000,000 and the services of 26,880 full-time employees because of eye accidents. These figures cover only compensable accidents—and only the legal costs of those compensable accidents.

The foregoing figures represent costs of compensable accidents only. What are the costs of the 240,000 noncompensable eye accidents which occur annually? According to the estimate based on this study of casualty insurance cases the average medical cost of a noncompensable accident is $9.26. It may be safe to assume that medical and nursing care for noncompensable eye injuries is

more costly than for other noncompensable accidents in the same ratio that is found in compensable accidents; however, since there are no figures available on this point, we shall use the figure $9.26 as the medical and nursing cost of the average noncompensable eye injury. Two hundred and forty thousand noncompensable eye accidents at $9.26 per case totals $2,222,400—the annual cost of noncompensable eye accidents. All the foregoing deals only with the direct, tangible, and easily recognizable costs. There are in eye accidents, as in all accidents, a host of other less easily recognizable and sometimes intangible costs which in the aggregate are far greater than the known, direct costs.

INDIRECT COSTS OF EYE ACCIDENTS

Eminent authorities[2] have pointed out that the indirect or hidden costs of accidents are *four* times as great as the cost of compensation and medical service. The calculations from which this four-to-one ratio was derived were based on the factors listed below. Compensation and liability claims, medical and hospital costs, insurance premiums, and cost of lost time (except when actually paid by the employer without reimbursement) are excluded.[3]

1. Cost of lost time of injured employee
2. Cost of time lost by other employees who stop work
    - *a*) Out of curiosity
    - *b*) Out of sympathy
    - *c*) To assist injured employee
    - *d*) For other reasons

3. Cost of time lost by foremen, supervisors, or other executives as follows:
    - *a*) Assisting injured employee
    - *b*) Investigating the cause of the accident
    - *c*) Arranging for the injured employee's production to be continued by some other employee
    - *d*) Selecting, training, or breaking in a new employee to replace the injured employee

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[2] H. W. Heinrich, of the Travelers Insurance Company, and Dean K. Brundage, Senior Statistician of the United States Public Health Service.

[3] Heinrich, *Industrial Accident Prevention*, p. 18.

e) Preparing state accident reports, or attending hearings before state officials

4. Cost of time spent on the case by first-aid attendant and hospital department staff, when not paid for by the insurance carrier.

5. Cost due to injury to the machine, tools, or other property or to the spoilage of material.

6. Incidental cost due to interference with production, failure to fill orders on time, loss of bonuses, payment of forfeits, and other similar causes.

7. Cost to employer under employee welfare and benefit systems.

8. Cost to employer in continuing the wages of the injured employee in full after his return—even though the services of the employee (who is not yet fully recovered) may for a time be worth only about half their normal value.

9. Cost due to the loss of profit on the injured employee's productivity and on idle machines.

10. Cost of subsequent injuries that occur in consequence of the excitement or weakened morale due to the original accident.

11. Overhead cost per injured employee—the expense of light, heat, rent, and other such items, which continues while the injured employee is a nonproducer.[4]

Careful investigation of almost any accident which resulted in an eye injury and what followed in the wake of that accident will show that the four-to-one ratio is not exaggerated. For example, an operator of a hot drop-forge press received an eye injury caused by flying hot scale.[5] The total cost of compensation and medical aid was only $22, but let us see what the incidental cost was. The injured man was a skilled workman, and the assistant foreman was obliged to take his place for three days so that an important order could be filled on time.

The incidental cost was computed as follows:

Cost of time lost by employees who depended upon the assistant foreman for advice and instruction . .	$ 50
Cost of time lost by the assistant foreman, in addition to that which he would have spent as indicated by foregoing item	30

[4] Heinrich, *Industrial Accident Prevention,* pp. 18–19.

[5] *Ibid.,* p. 27.

Cost of time spent by the safety committee in investigation of the accident	12
Cost of time lost by the injured man (paid by the employer)	10
Cost of time lost by other employees when the accident occurred	5
Total incidental costs	$107

Compensation and medical aid cost $22; incidental costs were $107. In this case the indirect costs were nearly five times as much as the direct costs.

If we accept the ratio of hidden costs to direct costs as four-to-one, the total yearly costs of eye accidents assume tremendous proportions. If the combined direct cost of compensable and noncompensable accidents is $22,000,000, the indirect costs, four times as great, are $88,000,000—a total of $110,000,000—the annual cost of industrial eye accidents to the employers of the United States. The cost to employees is almost as great, it will be shown later in this chapter.

EXTENT OF INDUSTRIAL BLINDNESS

The National Health Survey made by the United States Public Health Service in 1935–36 estimates the number of persons totally blind to be 107,000. This figure does not include the 10,000 or more blind persons in schools and institutions.[6] In the investigation of 2,800,000 persons upon which the National Health Survey was based all causes of blindness were classified as (1) disease, (2) accidents, and (3) congenital. Disease was responsible for 72.1 percent of all blindness; however, figures are not available to indicate what percentage of blindness is caused by occupational disease. It may be assumed that occupational hazards such as exposure to high temperatures or to poisonous substances may have been responsible for a number of cases in the groups classified as cataracts and other diseases of the eye.

[6] United States, Public Health Service, *Blindness—Amount, Causes and Relation to Certain Social Factors,* National Health Survey 1935–36, Bulletin No. 10, "Sickness and Medical Care Series," 1938.

Table 6

PERCENTAGE DISTRIBUTION OF BLINDNESS ACCORDING TO CAUSE[a]

Cause of Blindness	*Percentage Distribution* (One eye)		*Percentage Distribution* (Both eyes)	
All causes		100.0		100.0
Diseases		42.4		72.1
Known				
Cataract	15.8		19.3	
Other diseases of the eye	5.4		11.9	
Infections and parasitic	5.7		5.6	
Chronic	3.7		5.0	
Cerebral hemorrhage	2.7		3.7	
Ill defined				
Unknown	3.2		14.8	
Senility	2.9		8.2	
Other ill defined	3.0		3.6	
Accidents		51.9		20.6
Automobile	2.9		2.1	
Not automobile				
Occupational	19.1		7.8	
In the home	18.2		5.0	
In a public place	7.9		3.3	
Unspecified place	3.7		2.4	
Congenital and early infancy		5.7		7.3

[a] Based on Tables 1 and 6 in United States Public Health Service, *Blindness—Amount, Causes and Relation to Certain Social Factors,* National Health Survey 1935–36, Bulletin No. 10, "Sickness and Medical Care Series," 1938.

Accidents, considered as a group, accounted for one-fifth (20.6 percent) of the entire amount of blindness. Of those cases of blindness caused by accidents for which place of occurrence was reported, 43 percent were caused by occupational accidents. In other words, 7.8 percent of all blindness was caused by occupational accidents.

While this would indicate that industrial accidents are respon-

sible for a relatively small percentage of blindness, the situation is quite different in certain industries—those which we know to be especially hazardous. In the metal-mining industry, for example, three-fourths of all blind miners were blinded by accidents. Three-fifths of all blind coal miners were blinded by accidents. Two-fifths of the blind machinists and toolmakers, one-third of the blind mechanics, iron and steel workers, engineers and cranemen, railroad workers, blacksmiths and forgemen, brick and stone masons lost their sight as a result of accidents.[7]

BLINDNESS IN ONE EYE

The National Health Survey indicated that there are 425,000 persons in the United States blind in one eye. Of the cases studied, 51.9 percent were caused by accidents, 19.1 percent by occupational accidents. Again, as in the case of total blindness, cataract heads the list as the principal disease cause of blindness in one eye. (See Table 6).

COST OF BLINDNESS TO THE EMPLOYER

In terms of compensation authorized by the various states, as will be noted from Table 7, prepared by the Division of Labor Standards in the United States Department of Labor, the cost of total loss of vision in one eye ranges from a low of $1,000, in Oregon, to a maximum of $5,250, in Wisconsin.

In practically all states, blindness[8] is regarded as permanent total disability, and the compensation allowed for permanent total disability ranges, as shown in Table 8, also compiled by the United States Department of Labor, Division of Labor Statistics, from a flat rate of $30 a month for life, in Oregon, to a possible maximum payment of $25 a week for life, in New York State and in California. The figures vary from $3,000, in South Dakota, to $15,000, in North Dakota, for loss of vision of both eyes. These

[7] Best, *Blindness and the Blind in the United States,* pp. 39–40.

[8] There are wide variations among the individual states in their definitions of blindness; many states regard 20/200 (Snellen) or 80 percent loss of visual efficiency as constituting industrial or occupational blindness.

figures do not cover those states where compensation awards are made on the basis of a percentage of the employee's wage, paid for life without limitation as to total amount. In the latter states, in cases in which total loss of vision occurs, average awards may be considerably higher than the maximum mentioned in the foregoing. In New York State, for example, where maximum compensation is two-thirds of the wage for life, the average award for total blindness during a recent five-year period has been more than $19,000.[9]

So much for the cost of blindness and less serious eye injuries to the employers. There are heavy costs also to the injured employee and to the community in which he lives.

COST OF BLINDNESS TO THE STATE AND THE EMPLOYEE

There are some 80,000 industrial workers who have lost the sight of one eye and 8,000 others who have lost the sight of both eyes while working at their jobs.[10] This writer believes that these persons, blinded by industrial hazards, lose on the average $1,000 a year each in wages, a total of $88,000,000 annually. This estimate takes into account the fact that a very large proportion of these workmen were skilled machinists, lathe operators, forgemen, iron and steel operatives—highly paid, skilled workers.

To this total of $88,000,000 should be added a large part of the $12,000,000 a year spent by Social Security agencies for aid to the needy blind and the substantial sums spent by other relief and welfare agencies to aid families of workmen whose earnings have been stopped or reduced as the consequence of total or partial loss of vision due to industrial accident or disease.

CONCLUSION

A conservative estimate of the number of industrial eye accidents occurring in the United States each year is 300,000, or more than 7 percent of all industrial accidents. These accidents occur

[9] Based on material from the United States Department of Labor, Division of Labor Statistics.

[10] Based on findings in United States Public Health Service, *Blindness—Amount, Causes and Relation to Certain Social Factors.*

Table 7

WORKMEN'S COMPENSATION[a]

Maximum Amounts Which May Be Paid in Dollars for Loss of One Eye January 1, 1940

GROUP I

In this group of States compensation for temporary disability is allowed *in addition* to the allowance for permanent partial disability.

State	*One Eye*
Wisconsin*[b]	$5,250
Connecticut*	5,200
North Dakota*	2,000
New Jersey*	2,000
Ohio*	2,344
Arkansas*	2,000
Utah*[c]	2,400
	2,000
Arizona*[d]	1,650
	1,375
Alabama*	1,800
Maryland*	1,800
Nevada*	1,800
	1,500
New Mexico*[e]	2,250
	1,980
Washington*	1,440
	1,080
Colorado*	1,946
	1,456
Idaho[f]	1,440
Wyoming*	2,200
Oregon*	1,000
Rhode Island*	1,600
California*[g]	

GROUP II

In this group of States compensation for temporary disability is allowed *in addition* to the allowance for permanent partial disability, with certain limitations as to period.

State	*One Eye*
New York*	$4,000
Georgia*	2,000
Minnesota*	2,000
Kansas*	1,980
Illinois*[h]	1,800
Nebraska*	1,875
New Hampshire*	1,800
South Dakota*	1,500
Vermont*	1,500

GROUP III

In this group of States compensation for temporary disability *is deducted from* the allowance for permanent partial disability.

State	*One Eye*
South Carolina*	$2,500
Missouri*	2,360
Massachusetts*	
Oklahoma*	1,800
Montana*[c]	2,520
Indiana*	2,475
Louisiana*	2,000
Texas*	2,000
West Virginia*	2,112
Florida*	1,800
Michigan	1,800
North Carolina*	1,800
Iowa	1,500
Pennsylvania*	1,875
Tennessee*	1,600
Virginia*	1,600
Delaware*	*1,695
Maine[i]	1,800
Kentucky*	1,200

[a] Based on United States, Department of Labor, Division of Labor Standards Table "Workmen's Compensation—Maximum Amounts Which May Be Paid in Dollars for Schedule Injuries," January 1, 1940. *States followed by asterisks include loss of use.*

[b] Reduced if over 55 years of age.

[c] Figures show maximum with additions for dependents.

[d] Figured on basis of $100 per month wages.

[e] Additional 50 percent for failure to provide safety devices.

[f] One percent deducted for second-injury fund. [g] Cannot be determined.

[h] For injuries after July 1, 1939, add 10 percent. [i] May be increased by the commission.

mainly in the metal and metal-products manufacturing industries, mining and quarrying, building and general construction, and lumber and wood-products manufacturing industries. There is no such thing as a nonhazardous industry so far as eye injuries are concerned; wherever men and women are employed—in stores, offices, hotels, and restaurants as well as in factories, mines, mills, and even on the farm—eyes may be and are, seriously injured in large numbers. The chief causes of eye injuries, as indicated by most available reports, are, in the order of their importance: (1) flying objects, especially those set in motion by hand tools; (2) abrasive wheels; (3) corrosive substances; (4) electric flashes including welding; and (5) molten metal.

The cost of compensable eye accidents averages $350 per case in compensation and medical expenses and approximately four times that amount, or $1,400, in hidden or indirect costs. These figures are nearly twice as great as the average costs of injuries to all other parts of the body. Noncompensable eye accidents cost approximately $9 in medical expenses and $36 in indirect expenses. Sixty thousand compensable accidents, at an average cost of $1,750, and 240,000 noncompensable accidents, at an average cost of $45, adds up to a grand total of more than $110,000,000—the cost to industry of eye accidents in the United States during one year. The loss in wages suffered by the injured workmen and the cost of government relief for the injured men and their families amounts to an additional $100,000,000 a year.

Of the 107,000 persons who are totally blind, it is estimated that 7.8 percent, or 8,350, were blinded by occupational accidents.[11] A further, indeterminable number of cases of total blindness were caused by occupational disease. Of the 425,000 persons blind in one eye, 19.1 percent, or 81,000, owe their blindness to occupational accidents.

ARE SUCH LOSSES INEVITABLE?

More startling than these figures about the loss of vision and the loss of money is the fact—and it has been demonstrated to be

[11] *Ibid.*, p. 2.

Table 8

WORKMEN'S COMPENSATION[f]

Benefits for Total Disabilities—January 1, 1940

STATE	WEEKLY BENEFIT LIMITS			LIMITATIONS ON PERMANENT TOTAL				LIMITATIONS ON TEMPORARY TOTAL				NOTATIONS
	Percent Wages	*Maximum Payment*	*Minimum Payment*	*Time Limit*	*Amount Limit*	*Additions*	*Deductions*	*Time Limit*	*Amount Limit*	*Additions*	*Deductions*	
ALABAMA	55%	$18.00	$5.00[a]	550 weeks*	$7,950			300 weeks	$5,400			$5 a week after 400 weeks.
ARIZONA	65%			Life				100 months				
ARKANSAS*	65%	20.00	7.00	450 weeks	7,000			450 weeks	7,000			Law inoperative.
CALIFORNIA	65%	25.00	6.50	Life*				240 weeks	6,000			40% after 240 weeks.
COLORADO	50%	14.00	5.00	Life				Benefits payable during disability.				
CONNECTICUT	50%	25.00	7.00	520 weeks	13,000			520 weeks	13,000			
DELAWARE	50%	15.00	6.00	475 weeks	4,000		Partial Disability	475 weeks	4,000		Partial Disability	
FLORIDA	50%	18.00	6.00[a]	350 weeks	5,000	Dependents — to 60%		350 weeks	5,000	Dependents — to 60%		
GEORGIA	50%	20.00	4.00[a]	350 weeks	7,000			350 weeks	7,000			
IDAHO	55%*	12.00*	6.00	Life*		Wife and children[b]	[b]	Benefits payable during disability.*			[b]	$6 a week after 400 weeks.[b]
ILLINOIS	50%*	15.00*	7.50*	Life[c]					5,500*	[c]		Increase of 10% in benefits for injuries after 7/1/39.
INDIANA	55%	16.50	8.80[a]	500 weeks	5,000		Partial Disability	500 weeks	5,000		Partial Disability	
IOWA	60%	15.00	6.00[a]	400 weeks	6,000			300 weeks	4,500			
KANSAS	60%	18.00	6.00	416 weeks*	7,488			415 weeks*	7,470			No waiting period for P. T.
KENTUCKY	65%	15.00	5.00	416 weeks	6,000		Partial Disability	416 weeks	6,000		Partial Disability	
LOUISIANA	65%	20.00	3.00[a]	400 weeks	8,000			300 weeks	6,000			
MAINE	66 2/3%	18.00	6.00	500 weeks*	6,000			500 weeks*	6,000			From 8th day after accident.
MARYLAND	66 2/3%	20.00	8.00[a]	No limit	6,000			312 weeks	3,750			
MASSACHUSETTS	66 2/3%*	18.00	9.00[a]	Life*				500 weeks	4,500			50% after limits for T. T.
MICHIGAN	66 2/3%	18.00	7.00	500 weeks	9,000*		Partial Disability	500 weeks	9,000*		Partial Disability	Total for all compensation.
MINNESOTA	66 2/3%	20.00	8.00[a]	Disability	10,000			300 weeks	6,000			
MISSOURI	66 2/3%*	20.00	6.00	Life*				400 weeks	8,000			25% after 300 weeks.
MONTANA	50%	15.00	8.00	500 weeks	7,500	Dependents — to 66 2/3%, $21 a week and $10,500		300 weeks	4,500	Dependents — to 66 2/3, $21 a week and $6,300		
NEBRASKA	66 2/3%*	15.00*	6.00[a] *	Life*			[e]	Life*			[e]	After 300 weeks, 45%, $10 maximum, $4.50 minimum.
NEVADA	60%	*	$30 a month	Life		Attendant — $30 a month		100 months	7,200	Dependents — $10 a month		Maximum weekly benefit — Permanent — $60 a month, temporary $72 a month.
NEW HAMPSHIRE	50%	18.00	8.00	300 weeks	5,400			300 weeks	5,400			
NEW JERSEY	66 2/3%	20.00	10.00[a]	400 weeks*				300 weeks	6,000			Thereafter at reduced rate for emloyees undergoing rehabilitation training.
NEW MEXICO*	60%	18.00	10.00[a]	550 weeks	9,900			550 weeks	9,900			50% additional for failure to provide safety devices.
NEW YORK	66 2/3%	25.00	* [a]	Life				Disability	5,000			P. T.—$15, T. T.—$8.
NORTH CAROLINA	60%	18.00	7.00	400 weeks	6,000			400 weeks	6,000			
NORTH DAKOTA	66 2/3%	20.00	6.00[a]	Disability	15,000			Disability	*			No limit, but in practice ceases when permanent disability is determined.
OHIO	66 2/3%	18.75	8.00[a]	Life				312 weeks	3,750			
OKLAHOMA	66 2/3%	18.00	8.00[a]	500 weeks	9,000			300 weeks	5,400			
OREGON		$30 a month	$30 a month*	Life		Wife — $5, children — $8 each, monthly		Disability		Dependents — to $97 a month		Temporary Total — if wage less than $30, full wage.
PENNSYLVANIA	66 2/3%	18.00	9.00[d]	500 weeks	7,500		Partial Disability	500 weeks	7,500		Partial Disability	
RHODE ISLAND	50%	20.00	7.00	1,000 weeks	10,000			1,000 weeks	10,000			
SOUTH CAROLINA	60%	25.00	5.00	500 weeks	6,000			500 weeks	6,000			
SOUTH DAKOTA	55%	15.00	7.50[a]	No limit	3,000			312 weeks	3,000			
TENNESSEE	50%	16.00	5.00[a]	550 weeks*	5,000			300 weeks	4,800			After 400 weeks — $5 weekly to maximum limitations.
TEXAS	60%	20.00	7.00	401 weeks*	8,020			401 weeks*	8,020			From date of injury.
UTAH	60%*	16.00	7.00	Life*		Children — 5% each, up to 5		312 weeks	6,250	Children — 5% each, up to 5		Payments reduced to 45% five years from date of injury.
VERMONT	50%	15.00	6.00	260 weeks	4,000		Partial Disability	260 weeks	3,900		Partial Disability	
VIRGINIA	55%	16.00	7.00	500 weeks	6,000			500 weeks	6,000			
WASHINGTON		$35 a month — flat rate		Life		Dependents* Attendant — $25 a month		Disability		Dependents* Attendant — $25 a month		By schedule in act.
WEST VIRGINIA	66 2/3%	16.00	8.00	Life				52 weeks*				May be extended to 78 weeks.
WISCONSIN	70%	21.00		Life				Disability				
WYOMING		$50 a month — flat rate		Disability	5,000*	Wife — $20, children — $15 each, monthly*		Disability		Dependents — to $90 a month		Additions for dependents affect monthly rate but not total amount.

* See "Notations" column.
[a] Full wage if less than minimum.

[b] Weekly maximum raised to $13.10 for wife, $16 for wife and child or children. Partial disability deducted from 400-week period.
[c] 12% of weekly wage when payments equal death benefit.

[d] Full wage if less than $9, in no event less than $5.
[e] Partial disability deducted from 300-week period.
[f] From United States Department of Labor, Division of Labor Standards.

a fact—that 98 percent of this loss, human and monetary, is needless. Ninety-eight percent of all industrial accidents can be prevented. This is at least as true of eye accidents as of those resulting in injuries to any other part of the body. In the opinion of some of the most experienced safety engineers of America there is a greater certainty of preventing eye injuries than of preventing injuries to any other part of the body.

What is necessary to avert this needless waste of sight and money? Five things, which, briefly, may be summarized as follows:

1. The management of industries must realize that eye injuries can be prevented and must genuinely determine to prevent them. Even after 20 years of campaigning by the National Safety Council, the National Society for the Prevention of Blindness, and numerous other organizations, thousands of industrial executives still do not know or do not believe that accidents can be prevented, despite the fact that a number of companies have demonstrated that it is possible and have been perfectly willing to share with anyone their experience and knowledge of how it can be done.

2. Management must be willing and must have the courage to issue the administrative orders which will insure an equal determination on the part of their subexecutives—the supervisors and foremen—to prevent eye accidents. In many instances only a mandatory rule, strictly though diplomatically enforced, will accomplish this purpose. The average industrial executive prefers instead to leave well enough alone; he prefers to go on paying compensation for eye injuries or insurance premiums which relieve him of this financial risk without disturbing the routine of production or of employer-employee relationship, with the result that men are needlessly blinded or partially blinded in his shops every year.

3. The plant must be made physically safe and goggles, masks, and other protective equipment must be provided wherever needed. Too often, even now, eyes are lost simply because of the failure to install a guard which may cost a few dollars or to provide a pair of goggles costing a dollar or two or three, despite the

fact that a single case of total blindness in New York State may and frequently does cost the employer or his insurance underwriter $30,000. It is however, not enough simply to buy goggles and to install safety devices. Provision must be made for proper maintenance of safety equipment and proper fitting and refitting of goggles continuously if this equipment is to be conscientiously used.

4. There must be a continuous, sincere, and well-planned program of educating workers and their supervisors concerning the eye hazards of industrial occupations, their real causes, and methods of eliminating or counteracting them. Without such a continuous program, safety rules and safety equipment are largely ineffectual.

5. Finally, complete coöperation of the workers themselves is also necessary in the program for eye protection in industry. In this respect, too, some few plants have shown that it is possible to have throughout the year the complete coöperation of employees, while in the average plant the safety engineer, the manager, or the foreman continue to attribute to the workmen or to fear of stirring up labor trouble the main responsibility for accidents.

Chapter III

THE PROBLEM OF EYE DISEASES

OCCUPATIONAL DISEASES affecting the eyes may be divided roughly into five groups: (1) those resulting from accidents or mechanical injuries; (2) those resulting from exposure to injurious radiant energy (intense light or heat rays); (3) those resulting from use of certain chemicals or other toxic substances; (4) those resulting from inadequate or improper lighting and other abnormal working conditions and (5) those resulting from communicable diseases which, while not directly caused by any industrial process, may nevertheless be spread by unsanitary conditions and practices in work places.

Since the beginning of the safety movement a quarter of a century ago, industry has been well aware of the first two of these five groups and has concerned itself with protection against them almost as much as with other accident prevention. This was so chiefly for two reasons; first, in the first two groups of eye diseases causes and effects were more readily apparent than they were in the last three named groups; and secondly, permanent disability resulting from the first two groups of eye diseases was compensable under some of the earliest workmen's compensation laws.

Years ago, a few of the larger, more progessive industrial concerns undertook, to safeguard their workers, or some of them at least, against all disease hazards, as well as accident hazards, within their plants. With the extension of workmen's compensation laws in recent years to include a larger group of industrial diseases, industry generally is now increasingly concerning itself with protec-

tion against the disease hazards inherent in the use of poisons, in the existence of bad working conditions, and in the presence of communicable disease in the plant or neighboring community.

SCOPE OF COVERAGE FOR OCCUPATIONAL DISEASES

Occupational diseases are definitely recognized by 30 states and the District of Columbia. According to a recent report of the United States Department of Labor,[1] there are three usual methods of covering disability resulting from occupational diseases. Some of the states which compensate for occupational diseases list the specific diseases which are compensable, while in other states the law provides compensation for any disability resulting from an occupational disease. In a few states the workmen's compensation act uses the word "injury" instead of the word "accident," and the courts in some cases have construed this to mean that any injury resulting from an occupational disease is compensable. In Missouri occupational diseases are compensable when both employer and employee elect to be covered, and in Oklahoma the state insurance fund is authorized to insure employers against liability for occupational diseases.

The report further states that the following 30 states provide for compensation for all occupational diseases or for certain specified ones:

Arkansas	Massachusetts	Philippines
California	Michigan	Puerto Rico
Connecticut	Minnesota	Rhode Island
Delaware	Missouri	Washington
District of Columbia	Nebraska	West Virginia
Hawaii	New Jersey	Wisconsin
Idaho	New York	
Illinois	North Carolina	United States:
Indiana	North Dakota	Civil Employees' Act
Kentucky	Ohio	
Maryland	Pennsylvania	Longshoremen's Act

[1] Sharkey, "Principal Features of Workmen's Compensation Laws, as of January 1, 1940," *Monthly Labor Review,* March, 1940, p. 580.

To protect employers against false claims and to fix responsibility some states in this group not only specify the disease that is compensable but also name the process or occupation from which it must arise. States not recognizing occupational diseases as a legal responsibility have in some instances compensated workers disabled by disease at the discretion of the compensation commission.

Massachusetts, the first state to recognize occupational diseases, based its action on the court's interpretation that the phrase "personal injury arising out of and in the course of his employment" included occupational diseases. Maryland and Oklahoma have held that accidental injury may include diseases of gradual contraction, but generally speaking these states are not yet considered to have blanket coverage. Missouri has made provisions for employers to elect to come under the act for occupational disease if they choose. California has defined the term "injury" to include "any injury or disease arising out of the employment."

Minnesota lists 23 occupational diseases and Michigan lists 31. New York listed 28 occupational diseases before adopting a blanket coverage in 1935.

Since occupational diseases develop or accumulate over a long period of time, during which a worker may have several different employers, it is necessary to make provision for fixing responsibility. Minnesota, Michigan, and New York hold the last employer responsible for the disability, but the employer may appeal to the commission to have the costs for compensation properly distributed among the other employers who are liable.

Wider coverage of compensation laws has provided probably the greatest, but not the sole, stimulus to industry's growing concern with the prevention and cure of occupational diseases. The medical profession, industrial management, engineers, the many health education agencies, and various other forces all have helped bring about greater appreciation of the fact that in industry, as elsewhere, cleanliness, sanitation, and health-promotion measures generally pay substantial dividends in terms of efficiency and contentment of workers, wholly aside from the reduction of

insurance or compensation costs. Nevertheless, the unhygienic conditions under which employees are still permitted or compelled to work in certain plants subject them to a higher degree of exposure to communicable diseases than exists, for them, outside industry.

Any serious effort to safeguard a plant against industrial disease hazards calls for at least a general knowledge of those diseases which may affect the eyes, not only on the part of doctors and nurses, but on the part of safety engineers, safety inspectors, and all supervisors of working conditions. A brief summary of these diseases follows.

DISEASES RESULTING FROM MECHANICAL INJURIES

Mechanical injuries are responsible for a majority of the cases of eye diseases which develop among industrial workers. Foreign bodies, penetrating particles of steel, glass, and other materials, cuts, abrasions, contusions, and burns—any one of these may be the starting point for serious diseases in any part of the eye. Following is a brief outline of some of the eye diseases which may result from mechanical injuries.

DISEASES OF THE LACHRYMAL GLANDS

Chronic epiphora.—This condition, a constant overflow of tears, can be caused by burns and lacerations of the conjunctiva, the scars of which close the lachrymal duct; by lacerations of the lachrymal sac; or by fractures of nasal bones which result in pressure against or deformity of the lachrymal sac.

Chronic dacryocystitis—(or "watery eye").—A persistent local swelling at the inner angle formed by the junction of the eyelids. This can be caused by burns or lacerations about the lachrymal duct and fractures of the nose which injure the lachrymal sac.

DISEASES OF THE CONJUNCTIVA

Acute catarrhal conjunctivitis.—The eye is inflamed, and there is a feeling of smarting, burning or itching and a sensation of

having a foreign body in the eye; all these symptoms are aggravated by bright light. The condition can be caused by irritating smoke, a scratch, foreign body on the conjunctiva, acids and alkalies, and various germ infections.

Chronic conjunctivitis.—This follows acute conjunctivitis when the exciting causes are not removed.

Tularemia (oculoglandular type) Rabbit Fever.—This type of tularemia resembles conjunctivitis with enlargement of regional nodes. Infection is often due to the handling or dressing of diseased rabbits.

Symblepharon.—This adhesion of one or both eyelids to the eyeball may develop as an after-effect of trachoma, or it may follow the healing of conjunctival wounds caused by burns or scalds from acids and other caustic chemicals.

Pterygium.—A triangularly shaped membrane forms in the conjunctiva, with the apex to the cornea. It begins in one corner, usually the inner, and works toward the pupil. Not much is known about the cause of pterygium, except that persons exposed to wind and dust seem susceptible. Industrial cases have been found among masons, lime burners, plasterers, stonecutters, varnish workers, and farm laborers.

DISEASES OF THE CORNEA

Keratitis.—Several forms of this inflammation of the cornea may result from mechanical injury to the cornea.

Ulceration of the cornea.—This is a serious lesion which may result in blindness; often caused by infection of wounds.

Silicosis of the cornea.—Minute, scattered, superficial corneal scars are found in stonecutters, woodfinishers, paper-glass workers, lathe workers, and workers in related occupations. Recent investigations indicate that there may be some connection between silicosis of the eye and pulmonary silicosis.

DISEASES OF THE IRIS

Iritis.—This inflammation of the iris, accompanied by tenderness of the eyeball, pain, and great sensitiveness to light, can be

caused by penetrating wounds of the eyeball which reach or expose the iris.

Iridodialysis.—Detachment of the iris from its insertion can be caused by injuries from blunt objects.

DISEASES OF THE CHOROID

Acute choroiditis.—This inflammation of the choroid is caused by an infected penetrating wound of the eyeball.

Suppurative iridochoroiditis.—This is a pyogenic infection, a symptom of which is the appearance of pus in the vitreous humor. It may follow penetrating wounds of the eyeball, especially those caused by small chips of steel and other material that are not removed promptly. This disease may grow into panophthalmitis.

Panophthalmitis.—A purulent infection of all the structures of the eyeball.

DISEASES OF THE RETINA

Retinal hemorrhage.—It may be caused by retinal wounds.

Detachment of the retina.—A hole or a tear in the retina most commonly follows trauma, a blow or a jar. It may also be caused by a penetrating foreign body or by the penetration of a sharp instrument.

Commotio retinae.—The formation of an edema affecting vision for a short while can be caused by sharp blows.

DISEASES OF THE LENS

Cataract.—A condition of opacity of the crystalline lens may be caused by occupations exposing the eye to excessive light. Direct injuries to the eye such as a contusion or perforating wound which opens the lens capsule, cause acute cataract, the first signs of which may appear a few hours after the injury or later.

Displacement of the lens.—This may be caused by a sharp blow to the eye.

Siderosis of the eyeball.—Particles of iron oxide which spread through the eye by the lymphatic channels may cause this disease, which results in cloudiness of the lens. Some months later subcap-

sular changes occur and finally posterior changes which may result in blindness.

DISEASES RESULTING FROM EXPOSURE TO RADIANT ENERGY

Excessive radiant energy in the form of ultraviolet and infra-red rays, X-rays, and emanations of radium and other radioactive substances can be the direct cause of serious diseases of the eye. Some of the more common results of exposure to excessive radiant energy will be discussed here.

Among the most common ailments due to radiant energy is electric ophthalmia, or "flashed" eyes. This condition is a form of conjunctivitis with the usual symptoms—redness, irritation, and a feeling of "sand" in the eyes. Ordinarily there are no lasting serious consequences; however, there have been cases reported of loss of an eye caused by a neglected electric ophthalmia in which an infection set in. "Flashed" eyes are caused by either sudden or prolonged exposure to intense light. Most cases are due to exposure to welding arcs. The painful effects are due to the action of the ultraviolet rays.

Exposure to intense light may also produce lesions of the retina due to the action of infra-red or heat rays. Exposure to lightning flashes at close range, to welding arcs, or to the flash of light from a short circuit may all cause thermal lesions of the retina.

One of the most common diseases known to be caused by repeated exposure to radiant energy is "glass-blowers' cataract," to which not only glass blowers but also many other workers are exposed. Chief among these are attendants of blast furnaces, blacksmiths, stokers, bakers, kiln oven workers, and in fact all furnace attendants exposed to intense heat.

It has been recognized for many years that furnace workers, and glass blowers particularly, are susceptible to a special form of cataract of the eye. In the case of glass blowers, the cataract almost always appears first in the left eye, which is the more exposed to the light. When it has appeared first in the right eye, it has been found that the glass blower has been in the habit of turning his

right eye toward the oven. Recent medical research indicates that glass-blowers' cataract is caused by the effect of infra-red rays upon the lens. The indications are that X-rays and radioactive emanations can also cause cataracts similar to glass-blowers' cataract. Doctors F. H. Verhoeff and Louis Bell, who devoted many years of intensive study to this subject, declared that the great frequency with which glass-blowers' cataract occurs, its relatively uniform type, and the fact that it occurs first in the more exposed eye, show clearly that it is due chiefly to the action of radiant energy. This is supported also by the fact that the cheek shows a more marked area of discoloration on the side of the first-affected eye.

DISEASES RESULTING FROM USE OF INDUSTRIAL POISONS

The growing industrial use of poisonous substances known to be injurious to the eyes and to general health calls for more serious attention than this group of eye hazards has thus far received from safety engineers and others concerned with the protection of the life and health of factory workers. We already know of 94 separate industrial poisons of which 65 have an injurious effect upon the eyes. Many of these represent groupings of chemical substances similar in their effects, such as lead and its componds, benzol and its homologues, and chromium and its compounds. It is safe to say, therefore, that there are hundreds of chemical substances used in industry which may be harmful to the eyes.

Every industrial physician, industrial nurse, safety engineer, and industrial executive or supervisor concerned with safeguarding the health of his employees should have at hand the *Guide to Impairments to be Looked for in Hazardous Occupations,* by Louis I. Dublin and Robert J. Vane, published by the Bureau of Labor Statistics, United States Department of Labor, as bulletin No. 582, "Occupation Hazards and Diognostic Signs."[2] For persons interested in more detailed and comprehensive information concerning industrial poisons the two-volume Encyclopaedia,

[2] The research incident to this study was financed by the Metropolitan Life Insurance Company.

Occupation and Health, published by the International Labour Office,[3] is recommended.

A list of known toxic materials used in industrial processes which affect the eyes, the conditions resulting from exposure to these poisons, and the occupations which involve such exposure, as reported by Dublin and Vane, the International Labour Office, and other sources, will be found in Appendix I of this volume.

DISEASES RESULTING FROM POOR LIGHTING AND OTHER BAD WORKING CONDITIONS

The effects of poor lighting on production and on accident experience are discussed in more detail in Chapter VIII. It will be sufficient here to discuss the effects of poor lighting and other bad working conditions upon the eyes.

All refractive errors—myopia, hyperopia, astigmatism, and asthenopia, which can be remedied by the wearing of glasses—are affected to a greater or lesser degree by bad working conditions, especially poor lighting. Asthenopia (commonly known as eyestrain), for example, can be caused by continual exposure to glare. Hyperopia, or far-sightedness, has been associated with poor lighting and continuous work close to the eyes. Needleworkers, watchmakers, engravers, all persons doing close work are susceptible to hyperopia.

Other eye diseases can be aggravated by bad working conditions. Conjunctivitis[4] may be brought on by using the eyes for close work without glasses when they are needed, by reading in a bad position, by working in insufficient light or too intense a light, or by using the eyes when vibration causes a constant change of focus—as reading in a moving vehicle. In fact, conjunctivitis may be brought on by any undue strain or irritation to the eyes.

Nystagmus may be found among those workers who year in and year out subject their eyes to abnormal and unaccustomed motions. The miner may develop nystagmus because of constant im-

[3] American office, 734 Jackson Place, Washington, D. C.
[4] Lewis, Park, *What You Should Know about Eyes,* p. 41.

perfect fixation of his eyes on poorly illuminated objects; the commercial motor-vehicle driver may acquire nystagmus by constantly watching traffic without complete fixation; the compositor by watching the type which he is setting; the paper hanger and the painter by following their brushes in conjunction with the fact that their bodies are often thrown out of a vertical position, thus causing more strain on the visual apparatus. For like reasons locomotive engineers, draftsmen, jewelers, typists, textile workers, and others may acquire nystagmus.

This disease is characterized by continual short, rapid, and rolling involuntary movements of the eyeball. A person so afflicted usually complains of objects dancing before his eyes, headaches, dizziness, and general fatigue, all of which symptoms clear up quickly if a change of work is made. The involuntary movements of the eyeball characteristic of nystagmus may also be induced by occupational causes affecting the eyes through the central nervous system or by some extraneous cause. Nystagmus may, for instance, develop in a coal miner affected with carbon monoxide poisoning, the eyes responding to irritation or disease in the central nervous system. The great majority of cases of nystagmus among coal miners, however, is due to poor illumination or to faulty visual fixation of objects on the black coal face.

Miners' nystagmus is the best known and the most thoroughly investigated example of occupational nystagmus; it occurs, according to various authorities, in from 3 to 25 percent of coal miners. It usually appears between the ages of 35 to 40 years among men who have engaged in mining for many years. Coal miners are much more prone to this affection than are other underground workers. This fact is attributed by the Miners' Nystagmus Committee of the British Medical Research Council to the blackness from the coal face. Of all cases of nystagmus among underground workers investigated by this committee, 81.5 percent were found among miners who work at the coal face—that is, among those who actually drill, cut, or pick the coal. A large percentage of the persons affected by miners' nystagmus are undoubtedly predisposed to this disease through uncorrected errors

of refraction. One reason for this is that many miners will not wear glasses because they "cloud" or "steam" easily underground. Nystagmus is rare in metal mines in which there is good illumination and is much less frequent in coal mines with adequate illumination, whitewashing, and ventilation.

It is significant that cases of miners' nystagmus reported in the United States are considerably fewer in number than elsewhere. The electric illumination of most coal mines in the United States is undoubtedly responsible for this fact.

Treatment for miners' nystagmus should begin with discontinuance of work at the coal face or a complete change of occupation when feasible. This should be followed by rest, correction of refractive errors, and general building up of the patient, both physically and mentally. Few cases of nystagmus persist under such treatment. Usually all physical signs of the ailment leave within two years after the man has left coal-face work; many clear up in a shorter time.

Preventive measures include the correction of refractive errors and muscular instability; adequate illumination without glare; whitewashing of extensive portions of mine passageways and timbers; arrangement of working hours so that there may be opportunity for recreation in daylight; thorough medical supervision and maintenance of high physical standards among workers; and proper mine sanitation and air conditioning, particularly to eliminate carbon monoxide.[5]

VENEREAL AND OTHER COMMUNICABLE DISEASES

The percentage of venereal diseases among employees in industrial plants varies between one and 10 percent. While this percentage is comparatively small, venereal diseases are nevertheless a serious problem wherever large numbers of employees use common dining, washing, or other plant facilities. Aside from the possibility of contagion, venereal diseases are often directly responsible for heavy financial loss to employers—loss that can be

[5] International Labour Office, *Occupation and Health; An Encyclopaedia of Hygiene, Pathology & Social Welfare,* II, 1934, 262–71.

averted. Compensation awards have been made to employees who claimed disability due to occupational causes when the disability might have been traced to venereal diseases. Such awards are avoided by a more progessive policy of handling the venereal-disease problem in industry.

Until recent years most industrial concerns refused to hire persons with a venereal disease and discharged employees discovered to have such disease, with the result that workers attempted, more or less successfully to conceal their condition. The problem of discovering venereal diseases in employees and applicants for work has been complicated by the opposition of organized labor to compulsory physical examination. This attitude is attributed to the fear that the physical examination might lead to blacklisting because of actual or alleged physical defects. The applicant with a venereal disease found himself in a vicious circle. Having no job, he usually had no money; hence he could not pay for treatment. Having a venereal disease, he could not get a job. Forced to conceal his condition to obtain work, the person with syphilis or gonorrhea, who might have been cured, did not receive treatment, and venereal diseases increased in industrial plants because the sources of contamination were unknown.

Within the past year or two this state of affairs has been largely relieved by increased coöperation between employer and employee and a more enlightened attitude about the subject on the part of the public generally. Now more and more employers realize that venereal diseases can be better handled by adopting a less harsh policy. Such concerns retain the diseased employee, but make certain he is treated and in some cases provide treatment for him if he cannot afford it or in some way help him get necessary treatment from reputable doctors or clinics.[6]

It is common knowledge that venereal diseases may be spread among industrial workers by common use of towels or drinking cups and by unsanitary toilet and washing facilities and that venereal disease may very seriously affect the eyes.

It is not necessary here to discuss the moral and economic obli-

[6] Parran, *Shadow on the Land.*

gation of industry to protect its workers against the possibility of contracting such diseases within the place of employment. Nor is it necessary in this volume to discuss the means which may be employed in industry for the eradication of venereal diseases. Such information has been spread broadcast by the United States Public Health Service, the American Social Hygiene Association, the American Public Health Association, and other national and local organizations more directly interested in the cure and prevention of these diseases. It is intended, here, merely to emphasize the fact that every thoroughgoing effort to reduce the eye hazards of industrial occupations should include protection against the spreading of venereal diseases.

INFECTIOUS CONJUNCTIVITIS—TRACHOMA

Several forms of conjunctivitis are highly contagious. One of the best known and most feared of these is trachoma. The danger of trachoma and the other forms of infectious conjunctivitis lies in their epidemic nature. Whole communities may become infected, the disease may be carried from one person to another by means of towels, wash basins, and other things commonly touched in work places or in public, such as railings, doorknobs, or streetcar straps.

The symptoms of trachoma, or true "granulated lids," begin with slight redness and discharge from the eyes. There may be little pain, only an irritation as though from a foreign body under the lid. In this stage trachoma may be properly diagnosed and a complete cure may be effected. If the disease is allowed to continue, ulceration and general inflammation sets in which may last from one to two years and may result in total blindness. Recent developments in the use of sulfanilamide derivatives in the treatment and cure of trachoma have been highly successful.

Trachoma may crop up in practically any community. Because of the communicable nature of the disease and because its seriousness is little appreciated by many classes of laboring people—being called merely "red sore eyes" by many of them—the existence

of even a single case in any industrial community may expose that community to the danger of a trachoma epidemic. Following the outbreak of such an epidemic among steel workers and their families in Youngstown, Ohio, 242 cases of trachoma were discovered in four months. In southern Illinois 16 cases were found within two blocks in one mining town.

THE NEW ATTITUDE OF INDUSTRY

Within recent years a new attitude toward the health of employees and potential employees has been developed by progressive employers. Not so many years ago most business concerns refused to consider for employment a workman recognized as having trachoma or any infectious disease and men were commonly turned away at the gate for this reason. But what happened to these men? They went from one plant to another, assumed aliases, learned in some cases to conceal the symptoms of their illness, and eventually found employment. In time their condition would be discovered; they would be discharged, and would repeat the process. The technique of employing men was not then so highly developed as it is today. A worker with trachoma and a persistent spirit could within a year work for three or four weeks in each of a dozen plants.

The attempt to keep trachoma, venereal diseases, and other infectious diseases out of the plant defeated its own purpose. It did succeed in excluding many disease carriers, but those who were able to secure short-time employment in one plant after another exposed a greater number of fellow workmen to disease than if they had been employed permanently in any one plant. And the attempt probably was more expensive than the more intelligent, humane, and effective methods now used by progessive employers.

The policy of such employers today is still to discover every case of infectious disease among their employees and applicants for employment, but for another purpose—that is, to cure the disease wherever possible.

Trachoma, while still an eye disease against which industry

must be on guard, is not the serious problem it was some years ago. Trachoma now would be disclosed at the time of the pre-employment medical examination or periodic health examinations made in most large plants. This dreaded disease is better understood generally and is under better control because medical facilities are now more readily available in industrial communities.

CLEANLINESS AN IMPORTANT PREVENTIVE

The means that should be taken to prevent spread of trachoma, venereal diseases, or other infectious diseases in any industrial plant are the ordinary means which should be taken to avert the spread of any communicable disease. The first step in this direction should be elimination of the common towel in any form and the provision of adequate and thoroughly sanitary washing facilities. The old-fashioned short-length roller towel has been replaced by a variety of automatic and semi-automatic roller towels in attractive sanitary cabinets which—*when properly refilled*—provide each person with the equivalent of a clean individual towel fresh from the laundry, to be used by him alone. When, as is too often the case, the soiled roll of toweling is not promptly replaced, this device—no matter how beautifully nickled and mirrored—becomes as unsanitary as the old-fashioned roller towel long since legislated out of existence.

Many plants through failure to provide even the most inexpensive individual paper towels and through their general neglect of health education, encourage the use of common towels. The writer has in recent years seen common towels in use in printing plants, machine shops, general business offices, and in various other industrial plants.

Adequate and modern washing facilities with plenty of soap and hot water available at all times is as essential as the use of individual towels. The importance of adequate, modern, and well-maintained toilet facilities cannot be overemphasized. Because of the high potentiality of door knobs, flush valves, and water faucet handles as spreaders of infectious disease, the use of labyrinth entrances and of automatic flushing systems or of foot

pedal flushing systems are recommended to employers who would take every possible means to avert the spread of contagious disease.

Reasonable minimum requirements regarding sanitation in manufacturing establishments are described in detail in the American Standards Association safety code[7] on this subject, which is intended for use by employers and building owners and for adoption and enforcement by administrative authorities. A copy of this code should serve as a guide to those concerned with the design and construction of new work places and to those who wish to check the adequacy of existing facilities.

The industrial concern that wishes to secure maximum protection against industrial eye diseases will set up an adequate medical service, preventive as well as curative, for all its employees. The basic objectives of industrial medicine as outlined by both the American Medical Association and the American College of Surgeons[8] are:

1. To ascertain, by examination, the physical and mental fitness of employees for work
2. To maintain and to improve the health and efficiency of those already employed
3. To educate the worker in accident prevention and personal hygiene
4. To reduce lost time and absenteeism caused by illness or injury

An adequate medical service for an industrial plant, as outlined by both the American Medical Association and the American College of Surgeons, would include:

1. A definitely organized plan for the medical service
2. A definitely designated staff of qualified physicians, surgeons, and attendants
3. Adequate emergency, dispensary, and hospital facilities
4. Preëmployment and periodic physical examinations—to be made only by qualified medical examiners
5. Efficient care of all industrial injuries and occupational diseases
6. Reasonable first aid and advice for employees suffering from non-

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[7] American Standards Association, *Safety Code for Industrial Sanitation in Manufacturing Establishments,* Z4.1, 1935.

[8] Newquist, *Medical Service in Industry and Workmen's Compensation Laws,* p. 3.

industrial injuries and illnesses while on duty. For further professional care such employees should be referred to their own private or family physicians

7. Education of the employee in accident prevention and personal hygiene

8. Elimination or control of all health hazards

9. Adequate medical records, accessibly filed in the medical department under responsible medical supervision

10. Supervision of plant sanitation, and all health measures for employees by the physician or the surgeon in charge

11. An ethical and coöperative relationship with the family physician

12. The use of approved hospitals

A plant of any size, in most industrial areas of America may realize such a program, if it is sufficiently interested in protecting the life and the health of its employees—and its own financial stake. Only the large plant can, of course, afford one or more full-time physicians. There is hardly a community, however, in which there is not available for industry the part-time services of one or more physicians or surgeons, including ophthalmologists.

The situation with respect to industrial health services is succinctly summarized by the College of Surgeons[9] as follows:

> Until recently, the medical control of plant sanitation with the exception of a few industrial establishments, has not been very effective. Employers generally have not delegated this responsibility to their physicians or many of the plant physicians were not qualified by training or interest to assume such prerogatives. Not until the costs in dollars and cents were driven home by suits for damages and by occupational disease laws did the full significance of proper plant sanitation become apparent. Fortunately, employers are now realizing that they alone cannot cope with the problems of sanitation and employee health. Members of the medical profession are also aware of the lack of sufficient scientific knowledge in regard to the toxicology or allergy producing qualities of certain industrial materials and of the fact that further research in this field is required. Consequently the coöperative activity of employers, industrial physicians, safety engineers, chemists and other laboratory workers, in an effort to eliminate or control industrial health hazards, has never been greater than it is at the present time.

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[9] *Ibid.,* p. 2.

Chapter IV

THE PROBLEM OF DEFECTIVE VISION

INDUSTRY'S CONCERN with the detection and correction of defective vision should be as great as its concern with the discovery and elimination of accident and disease hazards. Industry's effort to solve the latter problem is inspired chiefly by the high cost of workmen's compensation for loss of vision, total or partial, resulting from industrial accidents or diseases. Although data are not readily available to prove the point, this writer hazards the guess that the cost to industry resulting from undiscovered and uncorrected defective vision among industrial workers is at least as great as the cost of the industrial accidents and diseases which cause total or partial blindness.

The unrecorded and largely unrecognized cost—to the worker and to his employer—of undiscovered and uncorrected defective vision is to be calculated chiefly in terms of: (1) potential improvements in the quality and quantity of production; (2) potential reductions in accident frequency and severity rates; (3) potential improvements in labor relations (between employers and employees); (4) potential improvement in public relations (between a company's employees and the public in whose good will and patronage the company is interested).

The employee who is subject to the tiring and irritating symp-

toms of uncorrected defective vision (and usually he is wholly unaware of the real origin of these symptoms) cannot for long apply his normal skill to his job, cannot keep his mind on his work so consistently as when he had normal vision, cannot stand up so well under the stress and strain present in many occupations, and certainly cannot maintain the capacity for reasonableness, courtesy, and coöperation of which he may be ordinarily capable. This employee is to be counted in hundreds of thousands, if not millions, judging from the experience of the companies mentioned in the following pages.

While opinion varies widely among authorities as to the percentage of defective vision among industrial workers, there is no longer need to speculate concerning the extent to which defective vision interferes with efficiency or increases industrial accidents. These questions have been answered by investigations in many plants of diversified operations. The results of these investigations all point to one conclusion: that purely as a matter of good business each employer should discover every case of seriously defective vision among his employees and should insist on its correction whenever correction by glasses or otherwise is possible. The experience of many employers indicates that it is good business also to give employees who need such help every possible assistance in getting the attention they need for their eyes and in getting glasses.

The wide discrepancies among published reports and estimates of the extent of defective vision in industry are due primarily to lack of uniformity with regard to definitions or understandings as to what constitutes defective vision; they indicate, for one thing, that many reports and estimates are based on the assumption that any deviation from normal or so-called perfect vision constitutes defective vision, irrespective of the degree of deviation.

Another explanation of the very large percentage of defective vision frequently reported is to be found in the statement by Dr. Elbert S. Sherman, surgeon of the Newark Eye and Ear Infirmary, that eye surveys in which the "chief interest is in selling as many pairs of glasses as possible . . . are the basis of some of the exag-

gerated statements of the very high percentages of industrial workers who need glasses."[1]

EXTENT OF SUBNORMAL VISION IN INDUSTRY

The larger and more progressive industries have in recent years begun to examine the eyes of all employees and of all applicants for employment. Below are the results of some examinations.

At the Pullman Company, of 11,000 men examined in one year, 58 percent had defective vision including 21 percent whose vision, the company reports, was "very bad."

At Cheney Brothers, silk manufacturers, Dr. Robert P. Knapp, medical director, reports that defective vision "runs perhaps as high as 75 percent in old employees and at least 25 percent in new employees," but that less than 2 percent have "uncorrectable" defects. Dr. Knapp adds, "these figures vary in the age groups; the younger the employee the fewer the defects, as a rule."

At the plant of the Bausch & Lomb Optical Company, 50 percent of all new employees were found to have some eye defect.

The Union Pacific Coal Company, operating ten coal mines in Wyoming, examined the eyes of all its mine-operating officials and employees and found that of 1,742 men, 1,306, or 75 percent, had defective vision. Seven of these men were wearing artificial eyes; twenty others had no vision in one eye; fourteen suffered from a progressive eye disease; one man was found to be incapable of counting fingers if held more than two feet from his eyes, another could see only at five feet objects which should be seen at 200 feet with normal eyesight.

These four companies, in different sections of the country, in divergent industries, conducting their investigations independently found that half or more than half their workmen had defective and uncorrected vision. In one of these plants three workers out of every four had refractive errors requiring correction by glasses.

The extent of subnormal vision among workers in various in-

[1] In a paper read before the convention of the Greater New York Safety Council, April, 1937.

dustries is reported[2] by Leo M. Mayer, Inspector of Optometry for the State of New York as follows:

INDUSTRY	PERCENTAGE HAVING FAULTY EYES
Garment workers	75
Office workers	53
Textile workers	52
Army applicants	21

The situation is presented even more graphically by Chart II,[3] p. 62.

The percentage of visual defects often is highest among the very workers who have the greatest need of good vision. For example, in the plants of the Whiting Davis Company, where a great deal of close fine work is done, the eyes of all employees were examined, and it was found that only 8.4 percent of them did not need glasses; 8.3 percent wore glasses which were satisfactory, and 83.3 percent needed new glasses.

Table 9

VISION EXAMINATION OF 1,000 APPLICANTS FOR EMPLOYMENT IN A SILK MILL

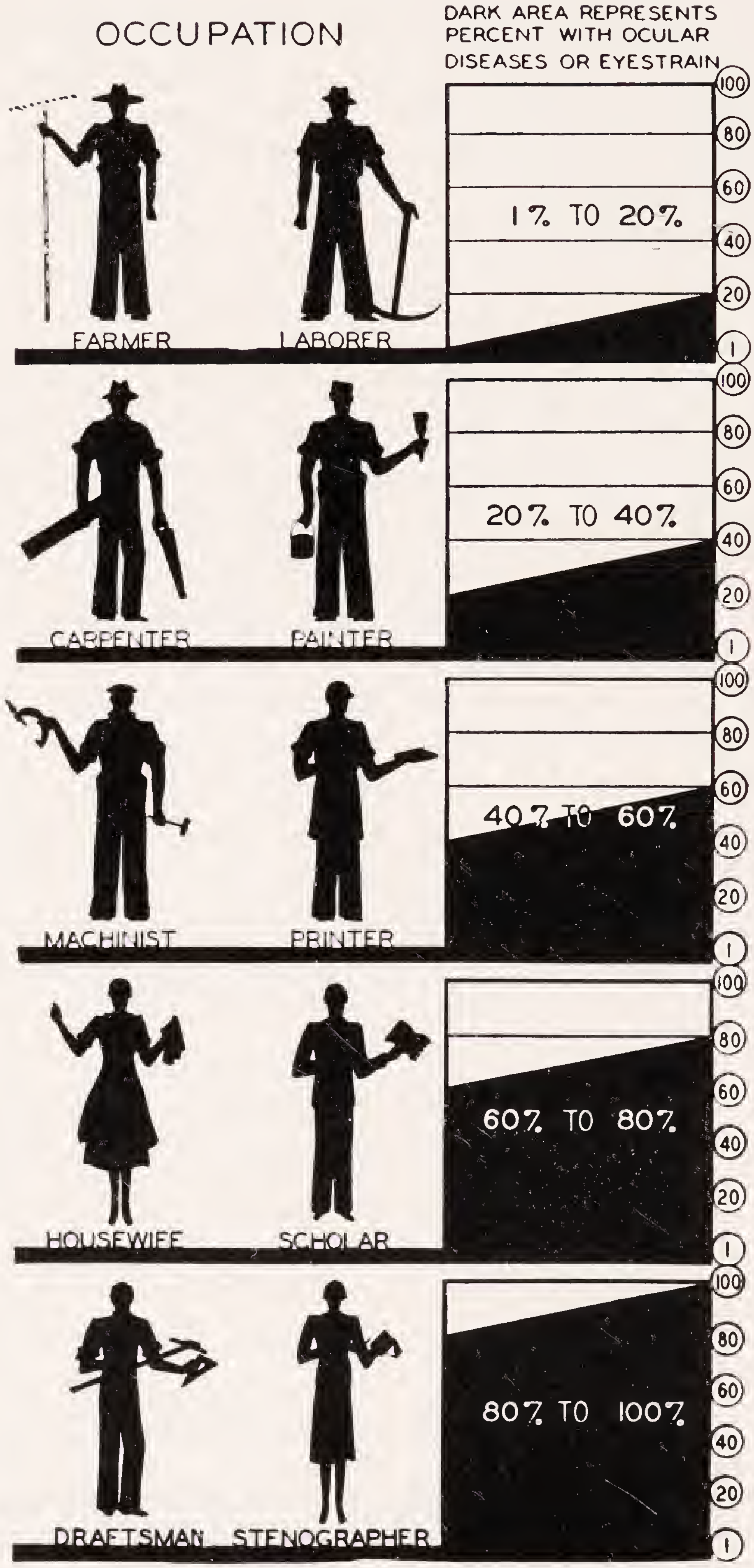
(By Snellen and Jaeger Tests)

Number Having Abnormal Vision (In percentages of the numbers in column 2)	*Applicants*
52.0	1,000 total
44.1	840 under 40 years of age
43.3	519 males under 40 years of age
45.1	321 females under 40 years of age
33.8	272, 2d decade
43.8	374, 3d decade
59.2	194, 4th decade
87.3	79, 5th decade
100.0	60, 6th decade
100.0	20, 7th decade
100.0	1, 8th decade

[2] Mayer, "Oh! Say, Can You See," *Safety Engineering*, LXXIII (March, 1937), 35.
[3] Morris, "Seeing for Safety," *Safety Engineering*, LXXIV (Sept., 1937), 9.

Chart II

PERCENTAGE OF SUB-NORMAL VISION IN VARIOUS OCCUPATIONS



One of the most important factors influencing the percentage of defective vision among industrial workers is age. Table 9 shows the incidence of visual defects at different ages, as found among workers in the mills of a large silk manufacturer.

Mr. Mayer reports the following percentages of defective vision among workers of different age groups in all walks of life.[4]

Age group	*15 years*	*30 years*	*40 years*	*50 years*	*60 years*	*Over 60*
Percentage of defective vision	23	39	48	71	82	95

The discovery of such conditions among their workers comes as a shock to most industrial executives; nevertheless these conditions are easily accounted for. Nature supplies long-range outdoor eyes. Modern life, however, demands that the eyes be used more intensely, for more close work, and for longer periods than was true of earlier generations. A further explanation of the prevalence of defective vision to such a marked degree is the fact that in some communities, in cities as well as in rural areas, people still buy spectacles from the ten-cent stores, push carts, or itinerant peddlers. Another factor which must be taken into account is the dislike for glasses felt by many workers, especially women, who think wearing glasses will focus attention on their age and thereby work to their disadvantage socially and economically. Because of such practices proper correction of errors has been neglected at a stage when the loss of vision might have been prevented.

PRINCIPAL EYE DEFECTS

Most eye defects discoverable among industrial workers are imperfections in the refractive powers of the eye. These are not to be confused with eye diseases, although refractive defects may be either the result or the cause of eye diseases. The four visual defects most common among working men and women, yet little understood by laymen, are those which produce nearsightedness (myopia), farsightedness (hyperopia), astigmatism, and

[4] Mayer, "Oh! Say, Can You See," *Safety Engineering*, LXXIII (March, 1937), 35.

presbyopia—the last, a condition of the eyes due to increasing years. Failure to correct these defects, the medical profession is agreed, is often the cause of disturbances in the nervous or digestive system and of other forms of serious sickness apparently unrelated to eyestrain.

The process of bending the incoming rays of light so that they fall on the retina and give a clear visual image is called refraction.

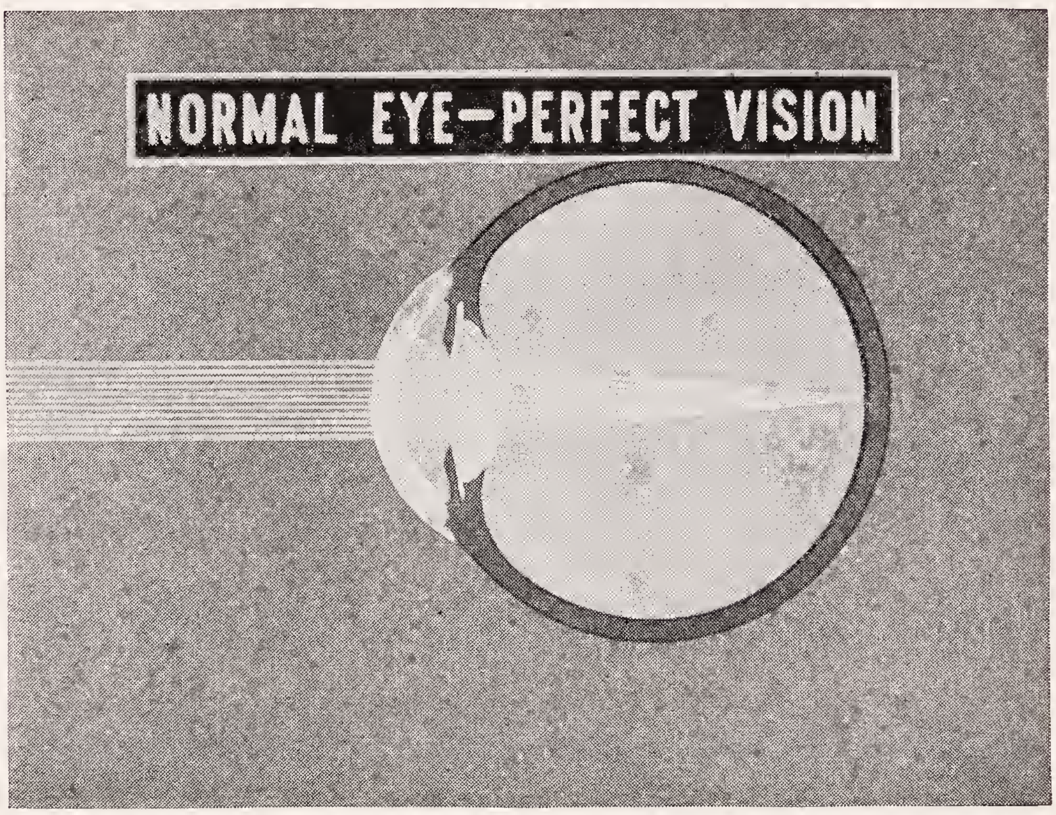


FIGURE 1

NORMAL EYE

Rays focus correctly on retina.

In the normal eye, with perfect vision, parallel rays of light from a distant object are perfectly focused upon the retina when the eye is completely relaxed. The act of focusing so that the divergent rays of light from near objects may fall on the retina is called accommodation. Errors of refraction, or visual defects, occur when the image of distant objects is not focused clearly while the eye is relaxed, thus causing excessive accommodation. It is this excessive accommodation which is responsible for the common symptoms of defective vision—fatigue, headache, nervousness, and general bodily disorders.

Farsightedness (hyperopia).—This is an error of refraction in a short eye is which the parallel rays of light from distant objects are brought to a focus behind the retina when the eye is at rest, that is, with accommodation completely relaxed. Because the farsighted person always gets a blurred image for distant vision when his accommodation is relaxed, vision for him requires some accommodation constantly, the amount of accommodation re-

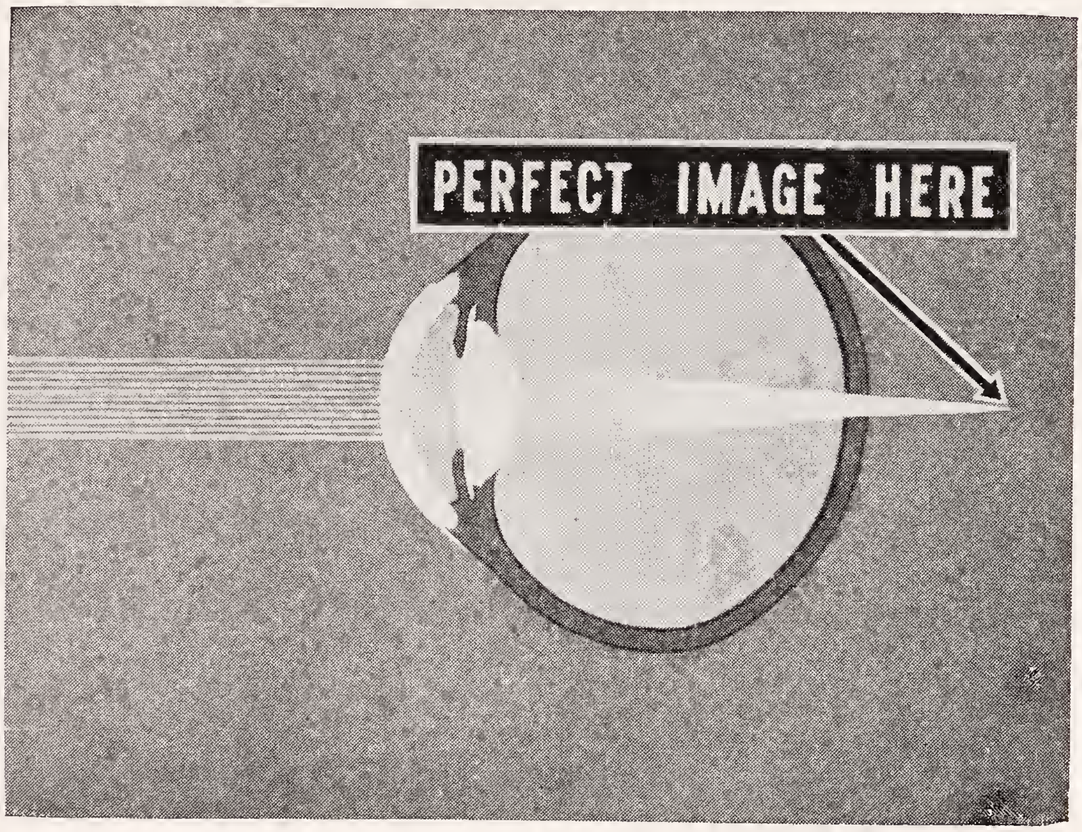


FIGURE 2

FARSIGHTED EYE

Vision is blurred.

quired depending upon the degree of farsightedness. This is one of the most frequent errors of refraction and is congenital. Since the farsighted adult eye must be under constant strain in attempting to secure even distinct vision, the ciliary muscles which determine the accommodation for near vision, by changing the thickness of the lens are constantly overworked. Only through careful examination by an eye specialist can the exact degree of farsightedness be determined. Whenever any marked degree of uncorrected farsightedness exists, close work is difficult for any length of time except under great eyestrain and usually is possible

only during the earlier years of productive life. Farsightedness which cannot be overcome by accommodation becomes more troublesome with age. When the accommodative efforts are unequal to the task imposed by near work, poor sight and eyestrain must result. The accompanying physical discomfort is manifested in headaches, neuralgia, inflammation of the eyes, watering of the eyes, abnormal intolerance of light, and other symptoms.

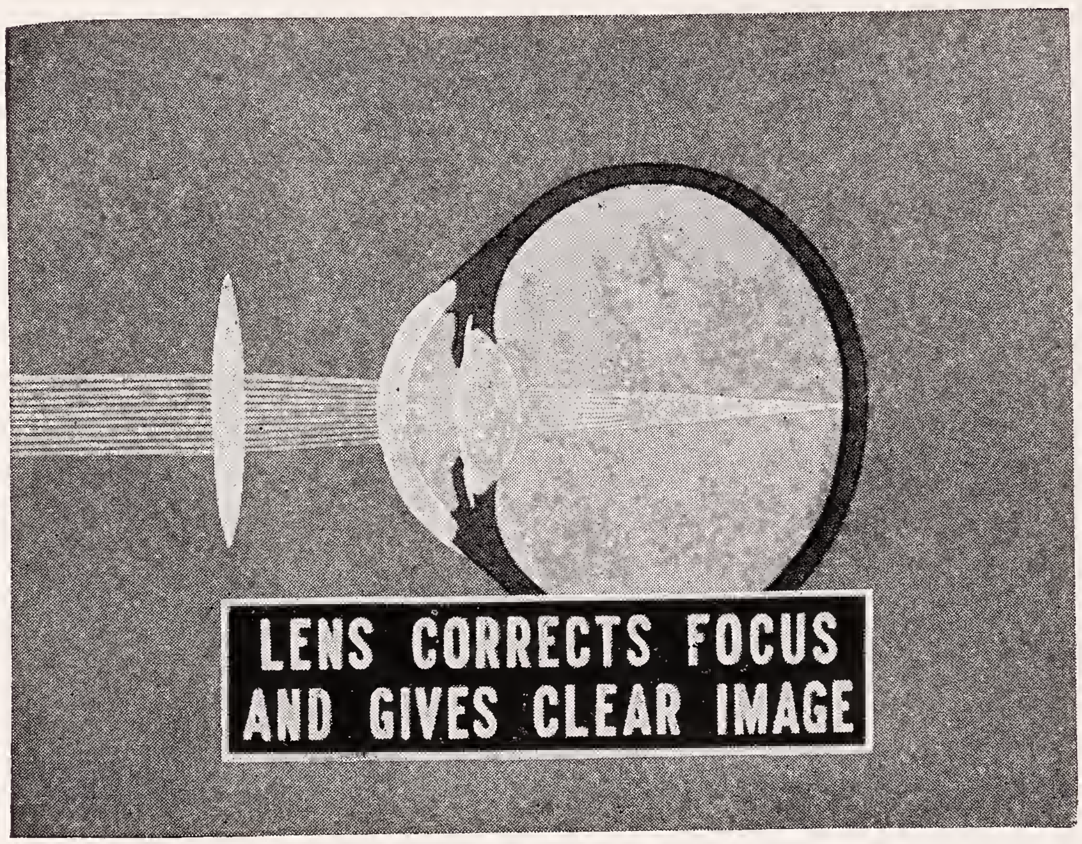


FIGURE 3

FARSIGHTED EYE CORRECTED

Converging lens gives clear vision.

Nearsightedness (myopia).—This is an error of refraction in a long eye in which parallel rays are brought to a focus in front of the retina instead of exactly on the retina. The nearsighted eye has distinct vision for close work, although when a high degree of myopia exists the point of distinct vision may be very close to the eye. It is often difficult for the nearsighted person to converge his eyes, as in reading. In the malignant form of myopia the retina may become stretched and torn by the elongating process, and hemorrhages may appear in the retina; the retina may become detached; the lens may become dislocated.

Industry is not usually responsible for the beginning of myopia, but may be responsible for its progression, especially in young employees. That serious cases of myopia can be the direct result of continued close work is shown in a report[5] by N. Bishop Harman, Senior Ophthalmic Surgeon of the West London Hospital. Mr. Harman selected 480 myopic patients for a study of myopia as an

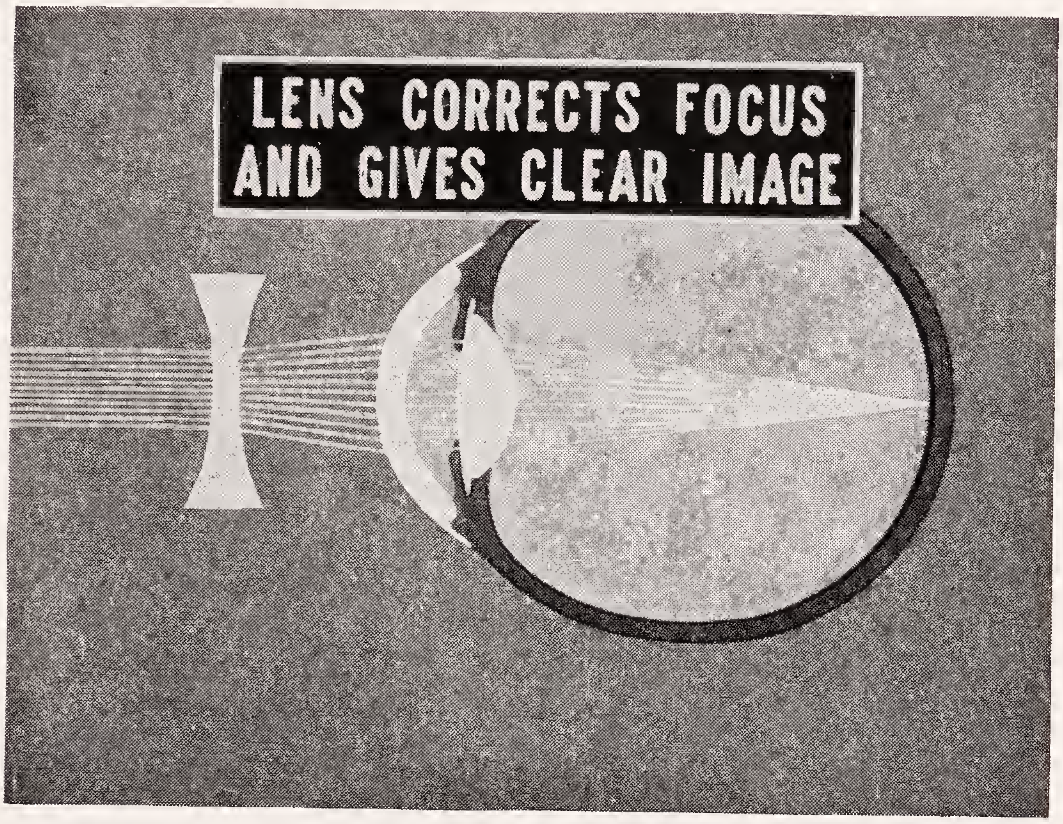


FIGURE 4

NEARSIGHTED EYE CORRECTED

Diverging lens gives clear vision.

industrial disease and divided them into two groups: those who habitually use their eyes for close work, and all others.

Among 183 who use their eyes for close work, Mr. Harman found that 97, or 53 percent, suffered what he termed eye failure which incapacitated them at some time during their work career and of these, 27, or 15 percent of the total, experienced permanent disability—in most instances total loss of vision of one eye.

As against this unfavorable picture, Mr. Harman's study showed that among the 297 who were not required to do close work, only

[5] Harman, "The Consequences of Myopia as an Industrial Disease of the Eyes," *Journal of Industrial Hygiene* IV (Jan., 1923), 371–74.

28, or 9.4 percent, suffered eye failure which incapacitated them, and of these only 7, or 2.4 percent, had a permanent eye disability.

In the cases of damage to the eyes there were 14 cases of detachment of the retina, 34 cases of degeneration of the macular region, 5 cases of gross vitreous hemorrhages, and 3 cases of rapid myopic cataract. These figures indicate the serious effect of close eye work on myopic persons.

When myopia exists in any degree, correction by properly prescribed and fitted glasses should be made. Correction usually results in greater efficiency through the improved mental and physical condition of the individual. Corrective glasses are, however, not enough. Myopia should be treated as a constitutional disease, and general hygienic supervision should accompany the ocular treatment. For example, congestion of the blood in the coats of the eyeball tends to distend them because of their inherent weakness, and one of the chief causes of congestion in the head and neck muscles is poor posture. Standing or sitting, the myope must watch his position. Illumination for the worker who has myopia should be of the best; glare should be avoided. When myopia is advanced, sedentary occupations should be avoided, especially where close work is involved. The myopic person should not subject himself to physical strain; detachment of the retina might result. The closer the work is held to the eye, the more likely is the chance to increase the myopia. The myopic worker should learn to do his close work at normal reading distance—from 14 to 16 inches. With proper physical care and corrective glasses, the person with low degree myopia may safeguard his eyes and do satisfactory work in a variety of occupations.

Astigmatism.—This is a defect of the eye in which light rays in different meridians are not brought to focus in the same plane. Regular astigmatism is usually due to malformation in the cornea which is generally congenital and can be corrected by glasses. Irregular astigmatism, caused by accident or disease, is much more difficult to correct. There is some degree of astigmatism in practically every eye, although the amount may be so slight as to give no inconvenience.

Dr. Charles H. May says:[6]

> There is always a diminution in the acuteness of vision both distant and near, varying with the degree and variety of astigmatism; it is least with simple astigmatism, more with compound astigmatism, and most with mixed astigmatism.[7]
>
> There is usually considerable *asthenopia* (weak sight or eye-strain), especially upon the use of the eyes for near work. These symptoms are similar to those occurring in farsight, but are apt to be more pronounced or continuous. They vary with the degree and variety of astigmatism, the amount of near work done, and especially the state of the patient's health. A small amount will, for instance, often give rise to severe nervous symptoms in a young, delicate or neurasthenic individual. The involuntary accommodative efforts of the ciliary muscle, made to diminish the effects of the error, cause continuous eyestrain and explain the frequency of asthenopia.

Early refraction, together with the use of proper glasses, is necessary in astigmatism if its evil effects, not only in impaired vision but also in impaired general health, are to be avoided. Astigmatism is one of the principal causes of eyestrain and of much inefficiency. Its relief will, as in the case of farsightedness and of nearsightedness, reduce the accident hazard, increase volume and quality of production, prolong the productive life of the individual workman, and improve the quality of his product.

Presbyopia or "Old Sight."—This is an impairment of close vision brought about through failure of accommodation due to advancing years. Few individuals can escape presbyopia in middle life. Usually its effects become apparent between the ages of forty and forty-five.

The presbyope is compelled to hold reading matter and other forms of fine work farther away than the usual distance from the eye in order to see clearly. A person in this condition is likely to use strong illumination; this produces contraction of the pupil of the eye and thus improves the definition of the matter being

[6] May, *Manual of the Diseases of the Eye*, p. 382.

[7] *Simple astigmatism*, in which one meridian is normal and the other is nearsighted or farsighted. *Compound astigmatism*, in which both meridians are either nearsighted or farsighted, but unequal in degree. *Mixed astigmatism*, in which one meridian is nearsighted and the other farsighted.

read or worked with. If the condition be uncorrected, the individual suffers from eyestrain, pain, fatigue, watering of the eyes, dimness of vision, and irritation of the lids, all of these symptoms being more marked when illumination is inadequate. Presbyopia has no effect upon distant vision, but when uncorrected it results in poor vision for near objects. Presbyopia may be corrected by properly fitted glasses. The condition is, however, progressive, and so glasses with greater magnifying power must be supplied from time to time.

Other eye defects.—The four types of refractive errors discussed in the foregoing are the most common eye defects and can all be greatly alleviated or altogether counteracted by corrective glasses. There are, however, other eye defects that should be taken into consideration. These may be due to fatigue in the ciliary muscle, to lack of balance of the motor apparatus of the eye, to tunnel vision, squint, or crossed eyes, color blindness, or other causes. While the number of such defects is few in comparison with the frequency of hyperopia, myopia, presbyopia, and astigmatism, their effect upon the worker in industry is worth noting.

In the light of work requirements of many occupations, squinting, or cross-eyed, persons are in effect industrially blind in one eye. This is due to the fact that squinting, or cross-eyed, persons can use effectively only one eye at a time. This condition can be prevented and in some cases can be cured by corrective exercise or training of the weakened eye muscles by use of properly fitted glasses.

Color blindness, on the other hand, cannot be cured. The most common form of color blindness is that in which red and green cannot be distinguished. Less common are cases in which blue and yellow are confused. In some rare cases, all colors appear gray. The percentage of color blindness is small, about 5 percent in men and less than one percent in women. There are, however, some occupations in which this visual defect would be highly objectionable or even dangerous. Transport workers, railway engineers, motor vehicle drivers, seamen, or electrical switch-

board operators who could not distinguish red from green would be a serious menace to others as well as to themselves. Furnace and kiln workers who must determine the temperature of their furnaces by the color of the flame would be handicapped in that occupation if color blind. The importance of a color sense to dye workers, textile designers, embroiderers, painters, and artists is obvious.

Since color blindness can be a definite hazard in industry, and since color blind persons may at the same time have completely normal vision in other respects, it would be advantageous for industrial plants to include a color blindness test in preëmployment examinations, so that persons so afflicted may not be unsuitably employed.

Eyestrain and Fatigue.—Fatigue of workers is one of the principal causes of industrial accidents and of production losses generally. Among the factors influencing fatigue are: the type of work; the length of the working period; environmental conditions of work; and the state of health of the worker. Monotonous operations performed over long periods without interruption are usually conducive to fatigue. Bad ventilation, poor illumination, and excessive noise also bring about undue fatigue. In many operations, however, the greatest single factor influencing fatigue is eyestrain.

Eyestrain, the result of excessive accommodation, can be caused by defective vision, by poor illumination, and by the constant requirements of fine, or close, eye work. Persons with normal vision may suffer from eyestrain quite as much as those with defective vision.

In an effort to relieve eyestrain and fatigue among industrial workers H. C. Weston and S. Adams, of the Industrial Fatigue Research Bureau of the Great Britain Privy Council, performed several experiments with workers in a number of plants. A study was made of three linkers in a silk hosiery factory.[8] These workers

[8] Weston and Adams, *The Effect of Eyestrain on the Output of Linkers in the Hosiery Industry*, p. 7.

hooked stitches onto needles, preliminary to the weaving of the toe of the hose. Because of the small size of the stitches, the operators worked with the needles about six inches from their eyes. Such close work calls for great accommodation. All three linkers chosen for study had normal sight, but they complained of headaches and a tired feeling which they did not associate with their work.

The study covered a two-month period, during one month of which the linkers worked under ordinary conditions; the second month they wore glasses providing slight magnification. Accurate record was kept of their output. Operators A and B were full-time workers with several years' experience; operator C was an inexperienced part-time worker. The following table indicates the average time (in seconds) per dozen hose for linking (and associated operations) for each experimental period:

SUBJECT	NO GLASSES	WITH GLASSES	PERCENTAGE OF DECREASE IN TIME DUE TO GLASSES
A	1,356	1,218	10.18
B	986	885	10.25
C	3,044	2,234	26.61

At the end of the study all three linkers said they felt much less tired at night and that they suffered much less from headaches. All three operators expressed a desire to continue wearing the glasses.

In further studies of the same kind Weston and Adams discovered that steel-ball examiners increased their output an average of 23.9 percent by wearing glasses, and menders in a wool mill increased their output about 25 percent by wearing glasses.

In each of these studies the majority of workers observed had normal vision—the type of work was such as to demand it; nevertheless, eyestrain and general fatigue were considerably decreased by the use of glasses. In the one case in which persons with defective vision were also observed, the work of persons with normal vision was improved to a greater extent than the work of those with defective vision by the wearing of the special glasses prescribed for this operation.

EFFECTS OF POOR VISION

Production efficiency.—The direct effect of subnormal vision on the quantity and quality of production, on the amount of spoilage of raw materials and finished products, and on the general contentment of the worker is so obvious as to need little further elaboration here. A few typical instances, however, may be of interest.

In a silk mill a comparative study was made to determine whether correction of defective vision results in greater productivity. Glasses were worn for the first time by all the operatives studied, and the production and efficiency of the operatives were compared over periods before and after they obtained the glasses. The first study compared the production of 13 velvet weavers during a three-month period before they wore glasses and a three-month period after they had obtained glasses. At the same time and under identical conditions a study was made of the production of another group of velvet weavers who had not been treated for defective vision and who were not known to have any visual faults. During the second three-month period the velvet weavers having presumably normal vision, whose eyes had not been treated, showed an average individual improvement in production of 1.19 percent; during the same period the weavers whose defective vision had been corrected by glasses showed an average individual improvement in production of 4.21 percent. A third group of velvet weavers who were wearing glasses for the first time in this same study showed average individual improvement of 3.32 percent as against the 1.19 percent improvement of the weavers whose eyes had not been treated.

A study along different lines of the relative productivity of quillers and beamers (other silk-mill workers) showed average individual improvement of 6.3 percent after the wearing of glasses (as compared to a similar period before their defective vision had been corrected).

Still another study, of seven miscellaneous operatives in the same mill and under an entirely different but equally careful

system of production measurement, showed an average gain of 11.13 percent in production efficiency following correction of vision by the wearing of glasses.

Lowered production is the most easily recognized result of fatigue. Another is slowness to respond to stimulation. A workman who is fatigued does not see, does not hear, does not understand, and does not act with his accustomed speed. For example, he may be working at a punch press, and he may actually see the plunger descending upon his fingers, yet slowness of reaction or of comprehension due to tired nerves may result in his failure to remove his hand in time to avoid losing his own fingers or causing serious injury to others.

Accident Frequency.—In addition to the accidents caused by fatigue due to defective vision, there are accidents resulting directly from faulty vision. While little statistical material is available to show the relationship between defective vision and the frequency of accidents, there is no doubt that poor vision is often the cause of accidents which are attributed to "carelessness."

Undoubtedly the marked reduction in industrial accidents reported in recent years is due in part to the greater attention which is being given to the eyes of applicants for employment and in many plants to the eyes of those employees who were engaged before the inauguration of this practice.

RESPONSIBILITY FOR CORRECTION OF DEFECTIVE VISION

Modern life requires close use of the eyes by an ever-increasing number of those gainfully employed, and the very requirements of employment seem to cause defective vision in a proportionally larger number of people. Two major steps can remedy this situation: first, the conditions which lead to eyestrain and resulting defective vision should be changed; second, all possible remedial measures should be taken for those who are now suffering from eye defects, whether congenital or acquired.

Illumination, sufficient and without glare, should be provided in factories, mines, mills, offices, stores, and other work places, as

well as in schools and homes, so that there shall be a minimum of eyestrain. Educational methods should be so modified that fewer young men and women will begin their work careers with the vocational handicap of defective vision. Correction of refractive errors, treatment of diseases, and operations, when necessary, will do much to relieve existing conditions. All of this requires the expenditure of money, but such expenditure must be regarded as investment to insure the health, happiness, and efficiency of the workers in industry and the community in general.

How shall the expenses be distributed? Shall the individual bear them? Shall they be a charge upon the public treasury or a charge upon industry? Distribution of the cost among all three would appear to be the most equitable arrangement. There has been enough experience in American industries to show that the correction of defective vision is a paying investment—profitable to the employer, to the employee, and to the community. The experiences of three employers who invested in the correction of substandard vision are described by Dr. Fowler in *Waste in Industry*.

At a rubber company an ophthalmologist is employed on a part-time basis, giving three hours a day to eye examination and visual correction. The mechanical work is carried out by a manufacturing concern that sends a representative to take frame measurements and adjust delivered glasses, the company advancing payment for the glasses at less than the usual retail rate and permitting the employee to meet this cost in small weekly payments. The entire expense of the ophthalmologist, however, is carried by the firm. Employees found to have substandard vision at the time of examination for employment or any subsequent examination are advised to avail themselves of this service. Most employees do, but there is no compulsion and no exclusion from employment because of minor deviation from normal vision. All employees reporting at the plant hospital and complaining of symptoms that might be due to eye troubles are referred to the ophthalmologist. Glasses were sold to about 1,000 persons per year during the first three years of this service.

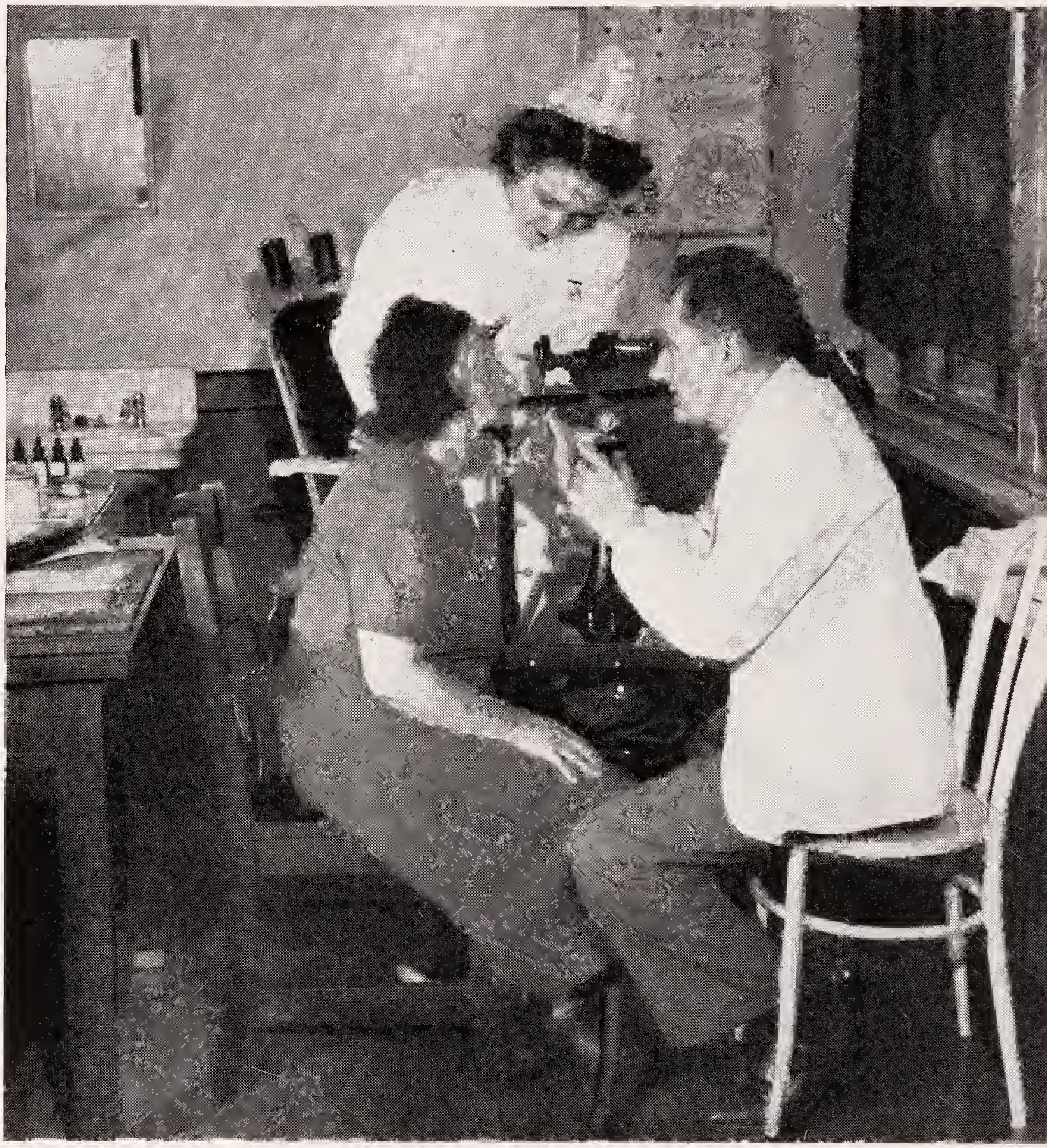


FIGURE 5

EYE CLINIC OF THE UNION HEALTH CENTER (NEW YORK)

Eye examinations and prescribed correction of refractive errors are part of the free services available to eligible members of the Sick Benefit Fund.

At a silk company and in a large mail-order house the method is somewhat different. Employees whose vision is below standard or who complain of "eye trouble" are sent to an ophthalmologist. While the employee pays for this service, it is rendered at a greatly reduced fee. This arrangement is possible because of the

large number of persons involved and the fact that the employers assure payment. Glasses are sold to the employees at reduced rates—and on the installment plan when necessary. The eye examinations are made on company time.

In the case of each of these companies, observations of foremen and superintendents and comments of the workmen them-

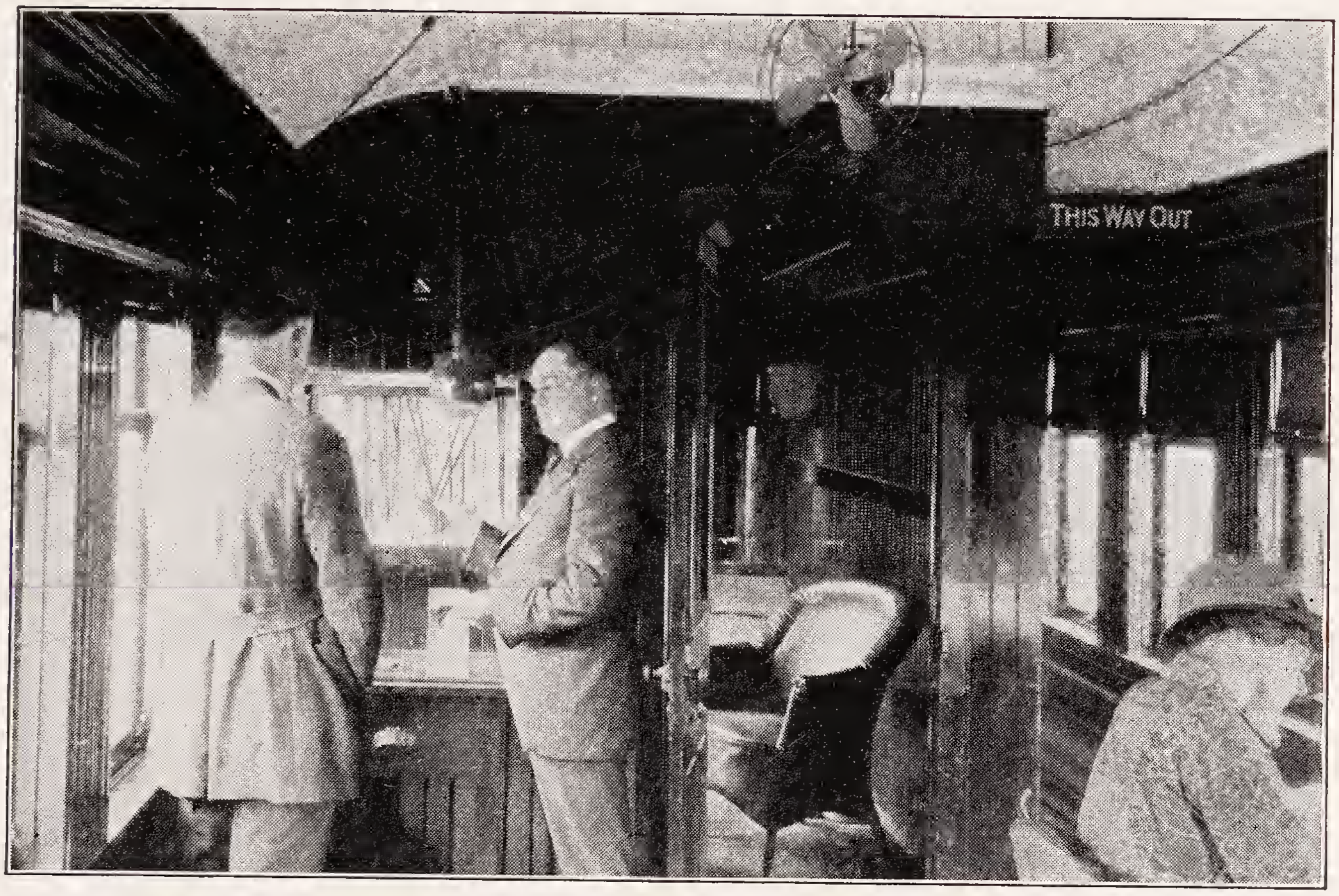


FIGURE 6

EYE-CLINIC CAR

This car is sent over the lines of a large railroad company every second year to examine the eyes of all its employees concerned with signals.

selves have been such as to lead to a continuation of the service year after year. Similar service has been rendered to employees with defective vision by the Pennsylvania Railroad, The United States Steel Corporation, The International Harvester Company, The General Electric Company, and numerous other concerns whose business judgment in such matters is unquestionable.

Two other interesting industrial eye clinics are those of the International Ladies' Garment Workers' Union and of the Delaware and Hudson Railroad Company. The former, known as the Union Health Center, is self-supporting and at the same time

renders medical, surgical, dental, and other health services to nearly 100,000 members of its locals. In 1940 the Union Health Center examined or treated more than 7,000 members for eye defects.

The Delaware and Hudson Railroad Company has for many years operated a traveling clinic in which the eyes of all employees concerned with signals are periodically examined. This eye clinic is a converted passenger coach, at one end of which is a reception room, or waiting room, seating six or eight persons. A partition separates the waiting room from the main office used by the oculist and his secretary.

Standard spacing for vision tests is provided. The dark room occupies a space at the side of the car, partitioned off from the office, and is about 20 feet long and 5 feet wide. This room is equipped with electric and oil lamps showing the various color devices used in railroad operations.

Most large industrial concerns and public utilities now recognize their responsibility, and the desirability from a purely economic point of view, for detection and correction of faulty vision among their employees. This is not, however, as generally true of smaller enterprises.

EYE EXAMINATIONS

The value to the employee and the employer of preëmployment and periodic follow-up eye examinations can hardly be overemphasized. The arguments for such examinations fall into four major classifications: (1) safety of workers; (2) determination of visual fitness for specific operations; (3) greater production efficiency; and (4) more accurate and equitable determination of compensation awards if disability results from accident or disease. Let us consider each of these factors briefly.

Safety.—Preëmployment examinations by a competent ophthalmologist will disclose the presence of eye diseases and sometimes other diseases which may affect fellow workmen because of their communicable nature. Epidemics of trachoma and other infectious eye diseases could be prevented by such eye examina-

tions. Furthermore, progressive eye diseases or other eye conditions that may be aggravated by minor injuries often can be checked or completely cured if discovered early enough through preëmployment or periodic eye examinations.

Determination of visual fitness.—An excellent example showing how poor vision may constitute a serious industrial hazard is the case of a structural steel worker who was found to have vision of 5/200. This man, who spent all his working hours walking girders hundreds of feet up in the air, could see only at 5 feet objects which the normal eye could see at 200 feet! An eye examination revealed this condition and put the man on the ground where he belonged. Normal vision is the first requisite in many specific operations, such as inspection of materials for flaws, weaving, sewing, and proofreading, to name just a few out of scores of occupations. Often eye examinations uncover the fact that an employee is not only unsuited for his work, but is being seriously harmed by it; for example, a proofreader with a high degree of myopia whose vision becomes progressively worse because of focusing his eyes constantly on close work.

A serious eye condition, while barring a worker from one type of work, may present no handicap in other kinds of work. A color-blind railroad worker could not be an engineer, but he might be a skilled shop mechanic. A myope of high degree should not use his eyes for close work, but he might be well suited for numerous varieties of out-door work or of long-range, non-detailed work of any kind.

Dr. M. Davidson, ophthalmologist of the New York State Department of Labor, has prepared the following table to illustrate general standards of vision necessary for specific operations:[9]

Near vision is required by fine mechanics, printers, garment workers and office workers.

Distant and indirect vision is required mainly by transport workers—truck drivers, locomotive engineers, aviators, seamen, etc.

Both distant and near vision and indirect vision are required by

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[9] Davidson, "Examination of the Eyes of Industrial Employees," *Sight-Saving Review*, III (March, 1933), 41.

those who deal with moving objects or those who have to move around stationary objects (myopes are particularly handicapped for these occupations).

Depth perception is required of mechanics, carpenters, crane operators, artists, draftsmen, etc.

Color vision is required by transport workers, embroiderers, signalmen, chemists, etc.

Light sense is required by sailors, chauffeurs, miners, night watchmen, photographers, etc.

Production efficiency.—As a result of examination of the eyes of his assembly workers, one manufacturer supplied nearly 20 percent of his employees with corrective glasses, introduced a rest pause to lessen eyestrain, and installed an improved lighting system. The quantity of output was increased 19.5 percent, and the quality of output, based upon the amount of work rejected by the inspection department was improved 16.2 percent. These substantial increases were the direct result of the correction of visual defects disclosed by eye examinations.[10]

Aside from other benefits, periodic eye examinations by an oculist of all the workers in an industrial plant may solve the problem of otherwise inexplicable drops in production, increased spoilage, or general inefficiency by uncovering the fact that bad working conditions—improper lighting, unaccustomed vibration, undetected fumes, and so forth have affected the eyes of employees.

Compensation.—In most states the workmen's compensation laws assume that every employee has normal vision in each eye at the time of employment, unless there is a reliable record showing that vision was below normal when the employee was engaged. There are innumerable cases in which employees have been awarded too much or too little compensation for an eye injury because the condition of the eyes before the accident was unknown or unrecorded. A typical case is that of a scrub woman employed in a weaving company.[11] This woman had a severe case

[10] Mitchell, "The Relief of Eyestrain on a Fine Assembly Process," *The Human Factor,* (London, England), X (Oct., 1936), 345.

[11] Moore, *Conserving the Eye Health of Industrial Employees,* p. 30.

FIGURE 7

PREËMPLOYMENT EXAMINATION TO DETERMINE MUSCULAR COÖRDINATION OF THE EYES

Such examinations are important prerequisites for employment.

Figure 8

PREËMPLOYMENT EXAMINATION FOR DEPTH PERCEPTION

Clear depth perception is important for efficiency as well as for safety.

of iridocyclitis, a serious inflammation sometimes resulting in total loss of vision, for which she claimed compensation. The reported cause of the condition was a piece of wool in her eye. The physician who examined her believes the severe inflammation present could not have developed in the few days between the accident and the examination. Had an examination been made and a record kept of the condition of this woman's eyes when she was employed there could be no question as to the cause of the disease or of the amount of compensation to be awarded.

RECOMMENDATIONS

It is recommended that the eyes of all applicants for employment be examined and that the correction of refractive errors be made a condition of employment, but that the employer exert every possible means compatible with good business to enable the employees who need glasses to secure them at minimum cost and, when necessary, by paying for them in convenient monthly or weekly installments. The eyes of all employees between the ages of 25 and 40 years should be examined at least once every two years. Persons 40 years of age and older should be examined once a year in order that the changes brought on by presbyopia may be discovered and corrected in time. Young workers, 18 to 25 years, who are myopic should be examined every six months to anticipate any of the serious eye conditions that may result from high degree myopia. It is particularly important that the eyes of men and women engaged in close or exacting work be carefully examined at time of employment and periodically thereafter.

The condition of the eyes of employees—even where vision has been corrected by glasses—and the visual requirements of the particular work that the employee is to do should be considered in assigning each worker to his job. Many companies do this through job specifications which are placed in the hands of the medical and employment departments. A job-specification card for each worker in his department is also given each foreman. The plant doctor, the employment manager, and the foreman each know

that a person engaged for any particular job must meet certain physical requirements; if the medical examination or subsequent observations by the doctor or the foreman show that an employee is unfit for certain work because of the condition of his eyes or indicate that the condition of his eyes, in consideration of the visual requirements of the job, predispose him to accident or to serious impairment of vision, he is returned to the employment department for transfer to other work.

Chapter V

THE PROBLEM OF FIRST AID

THE GREATEST PROBLEM in the first-aid treatment of eye injuries—as in the treatment of most injuries resulting from industrial accidents—is that of preventing infection. Machines, tools, raw materials, the products of manufacture, and the atmosphere itself are often contaminated with oil, grease, sand, dirt, or other bacteria-harboring material. Any wound received in a factory, therefore, may become infected if it does not receive prompt and efficient first-aid treatment. This situation, serious in itself, is aggravated in many industrial properties by the difficulty of getting workmen to seek treatment for injuries promptly at first-aid stations or medical departments.

In the case of certain types of eye injury this is true particularly because at the time of the accident there may be little pain or discomfort. A particle of metal or emery may penetrate the eye and the employee may not even realize at the time that he has received an injury which may have extremely serious results unless it is promptly attended to by a doctor or a nurse.

Each year there develop among industrial workers thousands of cases of infected eyes—many of them resulting in permanent, partial loss of vision or in total blindness—because of delays in securing first aid or because of self-treatment or treatment by fellow workmen. Of 42 cases of loss of vision among Pennsylvania coal miners in one recent year, nearly 50 percent were caused by infected corneal ulcers. In nearly every one of these cases blind-

FIGURE 9

WANTED—FIRST AID!

ness might have been prevented if the ulcer had received prompt and proper medical attention.[1]

In a plant where safety is receiving as serious attention as production the employees have been trained to report promptly at the hospital for treatment of all injuries—no matter how minor—and facilities have been provided for rendering such treatment quickly and effectively. The millions of dollars paid as compensation for eye injuries which become compensable cases only because of infection are evidence of the fact that in many plants workmen still are in the habit of neglecting slight eye injuries until through infection they become hospital cases or of permitting fellow workmen to substitute for oculists.

Just as harmful as the failure to apply promptly for first aid for eye injuries is the practice of hurrying injured workmen back to the job prematurely. This is frequently done during safety campaigns in an effort to influence the record of lost-time accidents; it is also sometimes tolerated during rush periods or when the injured worker is an important cog in the plant organization. The practice represents false economy and sometimes results in permanent disability or other serious consequences in cases in which normal convalescence would lead to complete recovery.

A good example of the effectiveness of trained first aid, both in the prevention of serious complications following minor eye injuries and in the saving of money to employer and employee, is the experience of a hardware manufacturing concern which in the three years 1935 to 1937, inclusive, had 90 cases of eye injuries, not one of which resulted in lost time or compensation payment.[2]

The employment manager of this company, which incidentally employs both a nurse and a doctor, attributes this good record to two facts: (1) the reporting of all injuries, no matter how slight, to the nurse and (2) referral of all eye cases by the nurse to the plant doctor; the nurse does not treat eye injuries beyond rendering first aid in case of burns or offering an eye wash in other

[1] Monahan, "Three Hundred Consecutive Eye Injuries," *Pennsylvania Medical Journal*, XXXVII (Dec., 1933), 219–22.

[2] North & Judd Manufacturing Company, New Britain, Conn.

injuries. All cases of eye injury must then be seen by the plant doctor.

A fine chip of steel, a particle of emery, a tiny wood splinter, or a grain of sand may get into the eye of a workman. He may be of the school of shop men who believe that it is perfectly all right to try to remove a particle from the eye with a freshly-chewed matchstick, a toothpick which has been accumulating dirt in a vest pocket, or the corner of a soiled handkerchief. Or he may be in a plant where there is no hospital, no nurse, not even a first-aid room or a proper first-aid kit. Under these circumstances the injured worker usually does one of two things: decides to worry through the day and then let his wife or neighbor remove the particle in the evening or the next day, or he asks a fellow worker to take it out. In either event the tiny wound caused by the particle in the eye may become infected because of delay or the bungling of an amateur.

Articles used by self-appointed "shop oculists" for removing particles from the eyes of fellow workmen include pocket knives, toothpicks, matches, tweezers, manicure files, shop files, draftsman's tools, and even the tongue of a fellow worker. The fact that employees in many plants still use such articles is evidence of the necessity for more thoroughgoing educational work among employees and of providing such first-aid facilities and personnel as will encourage injured workmen to apply for treatment promptly and to the proper person.

There are generally present, even in the normal eye, germs which find opportunity for developing serious infections through abrasions such as those which might result from the unskilled use of even a thoroughly sterile probe. It is therefore of utmost importance that any operation of this nature be performed by a physician who will have opportunity to keep the eye under observation for possible later developments that might prove disastrous. That is why any workman whose eye is injured, no matter how slight the injury may seem to be, should go at once to the company hospital, physician, or nurse, if such there be. If no physician, nurse, or safety engineer is employed for full time by

the company, adequately stocked and dust-proof first-aid kits should be readily available to foremen or to office men who have been instructed in their use, and such persons only should be the ones consulted in case of eye injury.

In this connection it is pertinent to cite the brief reference to "Medical Aid" in the United States Department of Labor *Minimum Standards for the Safety and Health of Workers in Manufacturing Industries* which says:

> (*a*) In every establishment where one or more persons are employed, suitable first-aid equipment shall be provided free of expense to the employees and available for use in case of injury.
>
> (*b*) Employers shall require all employees to apply promptly for first-aid treatment for all injuries sustained at work.
>
> (*c*) In every establishment one or more persons, in proportion to the size and needs of the establishment, shall have a complete course in first-aid, at least equivalent to that prescribed by the United States Bureau of Mines or the American Red Cross, and all employees, so far as practical, shall likewise be given such a course.
>
> (*d*) In every establishment where 100 or more persons are employed suitable accommodations, for which a physician or a trained nurse shall be responsible, shall be provided for the treatment of persons injured or taken ill on the premises.

Medical authorities are not in agreement as to what first-aid methods should be used by laymen. Dr. E. E. Willison, staff physician of the American Red Cross, for example, says:[3]

> Magnets, argyrol, flaxseed, etc. are positively not part of (laymen's) first-aid equipment. A bottle of sterile mineral or castor oil or a tube of bland eye ointment such as boric acid ointment or White's ointment and sterile dressings such as a bandage compress form all the needed supplies. . . . Removal of a foriegn body from the eye by a lay person in an industrial plant is always a doubtful procedure. Simply instill a few drops of the sterile oil or ointment into the eye and bandage. Send to a physician preferably an eye specialist.

Anything but the simplest sort of first-aid treatment of an injured eye, when attempted by laymen, may do irreparable dam-

[3] Willison, "Treating the Injured Employee," *Safety Engineering*, LXIX (May, 1935), 229.

age. On the other hand, simple and carefully performed first-aid treatment by lay persons trained in use of first-aid equipment can ease the pain and irritation of eye injuries, and in some cases materially decrease the seriousness of an eye injury.

FIGURE 10

A WELL-EQUIPPED FIRST-AID ROOM WITH COMPETENT PERSONNEL

Such rooms may prevent the serious consequences of infection.

The factory first-aid kit should contain, among other things, sterile gauze, cotton, and bandages, a syringe for flushing the eye, boric acid, and a bland sterile oil or eye ointment.

Factors to consider in all first-aid treatment of eye injuries are: (1) cleanliness and (2) prompt rest for the eye. The first-aid measures discussed in the following pages are based upon these two principles. It must be remembered always that first-aid treatment

of eye injuries should be followed by medical care under direction of a competent physician, preferably an eye physician. First-aid treatment is never sufficient by itself.

FOREIGN BODIES IN THE EYE

In cases of nonpenetrating particles—"dirt or dust in the eye"—the initial step in first-aid treatment consists of flushing the eye well with water—in many cases water alone will remove the particle. If this is not successful, be sure the hands of the person

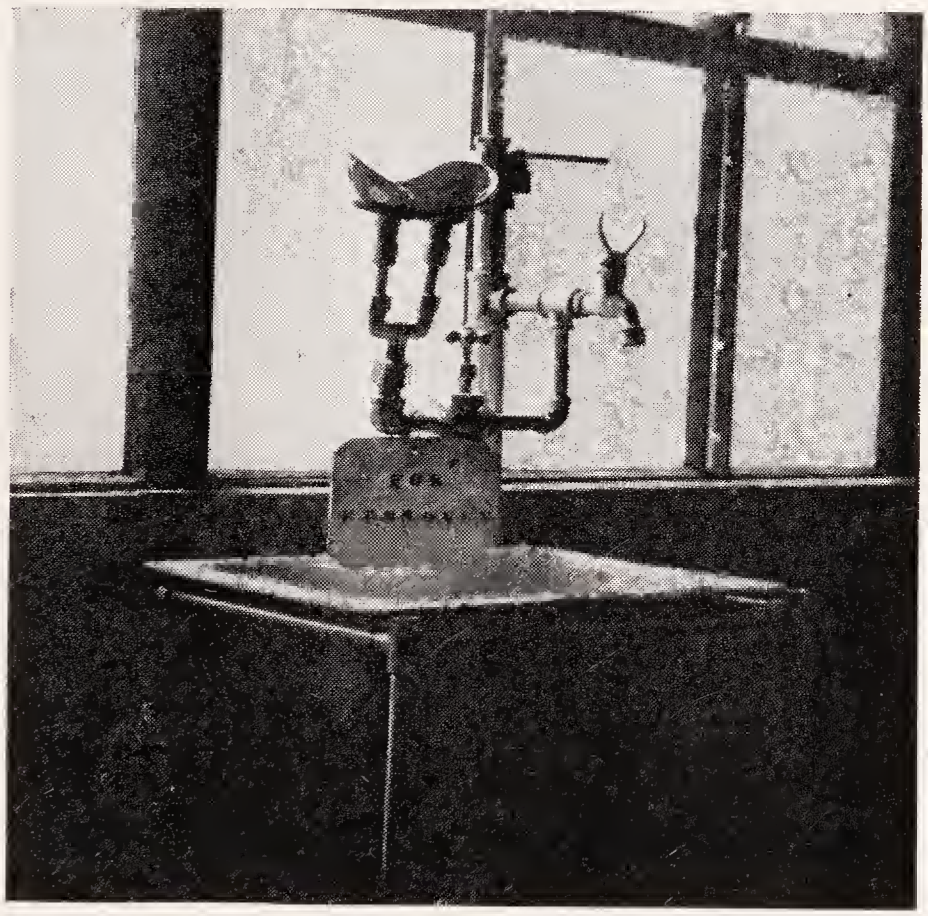

FIGURE 11

AN EYE-WASHING FOUNTAIN

This was devised for use in a public-utilities plant.

administering first-aid and the eyelashes of the patient are thoroughly cleansed. After separating the lids, remove the particle by dragging a small twist of sterile absorbent cotton, either twisted tightly upon its own fibers with a little tufted tail piece, or twisted about a matchstick with a tuft extending from the end, very gently over the particle. If one or two attempts do not remove the par-

ticle, flush the eye gently with boric acid or normal salt solution, instill a few drops of a sterile, bland oil, bandage lightly, and send to a doctor.

In the case of lime dust in the eye, copious flushing is of utmost importance—it may save the eye. A particle of lime dust in the eye, unless washed out at once, may cause severe burns with resultant scarring or perforation of the eyeball, impairment of vision, and permanent turning out of the eyelids.[4] The eye fountain illustrated in Figure 11 is well suited for thorough and convenient flushing of the eyes.

British authorities recommend use of a 10 or 15 percent solution of glucose in cases of lime dust in the eye.[5] Such treatment, however, should be left to a doctor or to a nurse working directly under a doctor's direction.

PENETRATING BODIES

All cases of penetrating injuries should be sent to a doctor. If the penetrating body is small, it is often impossible for the injured person to tell whether there is anything in the eye and the ordinary means of examination used by a general medical practitioner may not be able to determine it. In such cases it is of the greatest importance to determine by means of the x-ray if there is a foreign body within the eye, for if foreign bodies are not removed, they may eventually destroy vision.

If there is one regulation above all others which should be in effect in every shop, factory, and work place of any kind whatsoever, it is that there shall be no attempt made by any workman to remove from the eye of a comrade a chip or foreign substance of any kind which may have penetrated the eyeball. Many companies have such a ruling—the penalty for noncompliance often being dismissal of the offender.

In the absence of a physician, first-aid treatment of penetrating

[4] "Lime. Industrial Data Sheet D—Chem. 19," *National Safety News,* XXXIII (Feb., 1936), 38.

[5] *Minton,* "Industrial Eye Injuries," *Industrial Welfare and Personnel Management,* XX, (July, 1938), 265-71.

injuries should consist only of instillation of a few drops of sterile oil and a light bandage to rest the eye. The injured worker should then be taken promptly to an eye physician.

CHEMICAL BURNS

Because of the pain usually incidental to acid, caustic, and other chemical burns of the eye, treatment of such injuries is, fortunately, not complicated by delays and amateurish efforts, such as are described in the foregoing paragraphs.

Clean running water should be available for washing hands or irrigating eyes on which the chemicals may have splashed. An eye fountain, such as that shown in Figure 11, is ideal for this purpose. A good emergency treatment is to place the victim on his back and thoroughly to irrigate the eyes, lifting the lids and enabling the water to reach as far thereunder as possible. A small flexible tube from which a moderate jet of water can be directed into the eyes should be at hand. If no better way is possible, the injured worker should immerse his head far enough into a pail of water so that he may open his eyes under water and thoroughly cleanse them of the irritant. If the plant is equipped with first-aid kits, then apply bichloride salve, bandage the eyes, and send the injured person to the doctor. It is important to dilute the chemical in the eye by water irrigation as quickly and as thoroughly as possible.

EYE BURNS FROM CAUSTIC SODA

In the manufacture or use of caustic soda workmen are likely to be burned severely unless constant care is exercised to prevent the spattering of liquid caustic soda and the flying of chips of solid caustic soda when opening packages or when breaking up large pieces. The safest and most effective treatment for burns from caustic soda—as well as for any other alkali or acid burns in the eye—is water, water, and more water. The value of water flushing as a first-aid treatment of the eyes cannot be stressed too highly. Many plants in which there is extensive use of caustic soda provide certain neutralizing agents such as dilute acetic acid or zinc

sulphate for first-aid treatment. These, *when used properly,* can be very effective. Diluted acetic acid at once neutralizes caustic soda and converts it into harmless sodium acetate, stopping its injurious action upon the flesh.

This remedy, extensively used, is prepared from chemically pure commercial acetic acid, by diluting it to an exact content of 2 percent actual acetic acid. If the commercial acetic acid be of 30 percent strength, one quart of it is added to fourteen quarts of water to give 2 percent strength. After this dilution the acid is analyzed to make sure that its strength is 2 percent. After the eye is thoroughly washed with this preparation a bland oil is applied. It is important that no absorbent cotton be used for cleansing the burn, because fibers of cotton become embedded in the wound.

Bottles containing the diluted acetic acid should be placed at frequent intervals throughout the plant, and workmen should be trained to use it immediately whenever anyone has got caustic in his eye.

As there are those who feel that diluted acetic acid wash does not measure up to the requirements for treatment of eye burns so successfully as might some other treatment, it should be stated that a 1 percent solution of zinc sulphate as a relief measure has been in continuous use by one company for many years, in hundreds of cases, regarding which its personnel director writes:

> In the comparatively few cases where loss or impairment of vision has occurred from caustic eye burns, we feel confident that either there was insufficient flushing of the eye with zinc sulphate, or else the flushing was not done soon enough after the injury occurred.

The superior advantages claimed for the use of zinc sulphate over the use of a diluted acetic-acid wash are that the former is less irritating; that it provides complete reaction, rather than an equilibrium reaction, as does acetic acid; and that it has an antiseptic quality of known value.

The procedure for treatment of caustic burns of the eye in the company referred to is described as follows:

> We have distributed throughout our caustic buildings, distinctly marked, small boxes each containing a 12-ounce bottle of 1 percent

zinc sulphate solution and one or more eye cups. These boxes are kept supplied with the solution.

When a workman receives a splash of caustic in his eye, his first thought is to get the zinc sulphate solution, and we have trained them to keep the location of these boxes pretty well in mind. It is a fact, however, that some other workman, on hearing his cry, will get the solution to him. The eye is thoroughly washed at the point where the caustic is received, and then the man goes to the dispensary as quickly as he can get there. In the dispensary the man is laid out on the table and more zinc sulphate is applied. Of course, the pain is severe so we then administer cocaine (2 percent), and after this repeat the dose of zinc sulphate. By this time we are pretty sure that the caustic is neutralized entirely, so we apply more cocaine, then olive oil, apply a cold compress, and send him to the physician. The after-care of such an eye-burn is exactly the same as for any burn or irritation of the eye, to permit of proper healing and control of possible adhesions. Ice packs are kept on the eye while the pain is severe, and this usually makes a patient comfortable.

Proper and quick neutralization is the essential treatment, and by quick neutralization I mean that received a few seconds after the caustic has entered the eye. Bad burns are the result of waiting until the patient can get to the dispensary.

For acid burns we lay the same stress on proper and quick neutralization with sodium bicarbonate (c.p.), and follow this with the cocaine treatment and olive oil. For toluol and benzol splashes (where the result is not necessarily a burn, but intense irritation, and this is true with toluol fumes) our treatment is cocaine (2 percent), letting the patient stand with his eye open in front of a fan to evaporate the benzol or toluol. I refer particularly to toluol and chlortoluol, with its derivatives, as this is where the intense irritation is found. We also find that steam (properly regulated) is very effective for this purpose.

ACIDS AND CAUSTICS

The acids and caustics most commonly used in industrial processes are: nitric acid, sulphuric acid, mixed acid, hydrochloric acid, hydrofluoric acid, carbolic acid, oxalic acid, picric acid, acetic acid, carbonic acid, hydrocyanic acid, alcohols, ammonia, caustic soda, caustic potash, soda ash, and lime. Here again the first rule is flushing with "water, water, and more water." The management of any plant using such acids or caustics to any extent

whatever should acquaint itself with and insure the use of safe methods of handling them. Plants engaged in manufacture of acids and caustics are usually equipped with proper safeguards and first-aid paraphernalia, but the plant which uses acids or caustics only occasionally does not give sufficient care to storing, carrying, and applying the acid, and is not usually prepared to render prompt and effective first aid.

The National Safety Council presents valuable information[6] concerning first aid in accident hazards from acids and caustics, which may be summarized as follows:

Treatment of chemical injuries and illnesses should be left wholly to the physician in charge. A workman's life, however, may depend upon the immediate administration of relief, so first-aid remedies, with instructions for their use, should be readily available at all times. Some one person should be made responsible for the quality and quantity of remedies kept in workrooms and at first-aid stations and at least one person trained in rendering first-aid should be immediately available at all times.

For all chemical burns, physicians recommend the immediate use of clean water in large quantities. Even substances insoluble in water may be mechanically removed from the skin surface by flushing. Some employers have installed shower baths in or adjacent to each workroom, under which a man may stand and be deluged with water in case of chemical burns. In locations where showers cannot be provided, a flexible water hose or several buckets of clean water should always be easily available.

The action of most acids and caustics on the eyes is very rapid and may cause blindness unless washing with water is immediate. Directing a moderate jet of water into the opened eyes from a small flexible hose is very effective. Other methods are to plunge the head into a vessel of clean water and wink the eyes rapidly, or to allow the water from a bubbler drinking fountain to flow into and flush out the eyes.

Sometimes large bottles of counteracting solutions are placed on special racks in the workrooms, but the best authorities generally agree that using plenty of clean water is better than trying to use neutralizers. Neutralizers if used, should be applied only under the doctor's orders.

[6] National Safety Council, Acids and Caustics, "Safe Practices Pamphlet," No. 25, 1938, p. 2.

First-Aid for Chemical Burns. The following procedures are recommended by some doctors:

(*a*) For acid-burns—nitric, sulphuric, mixed, hydrochloric, acetic, oxalic and picric (for oleum, first wipe off oleum with a clean cloth)—bathe freely with water and apply a saturated solution of bicarbonate of soda.

(*b*) For alkali burns—caustic potash, caustic soda, ammonia, lime, and soda ash—bathe freely with water and then apply a 2 percent solution of acetic acid.

(*c*) For hydrofluoric acid burns—bathe freely with water and then with diluted ammonia water.

(*d*) For carbolic acid burns—wash at once with water, then with grain alcohol or sodium sulphate.

(*e*) For hydrocyanic acid burns—wash with water, then immediately drop on the burn either ammonium polysulphide or a solution of potassium permanganate.

"FLASHED" EYES

"Flashed" eyes, or electric ophthalmia, is caused by prolonged exposure to injurious ultraviolet rays. Among those exposed to this hazard are persons engaged in or near by such operations as welding, cutting (oxyacetylene and other gases), electric repair work, motion-picture studio work, motion-picture machine operating, and studio photography. In electric arc welding cases of "flashed" eyes are increasing, not especially among the welders themselves, but rather among welders' assistants and and other persons working in the vicinity.[7]

Welders are invariably protected by masks or goggles containing "welders' green" glass. Where employers fail to provide adequate protection for those who work near welders by completely screening the welding operation, the danger of "flashed" eyes exists for all employees and visitors who come within close sight of the welding operation. Protection against this hazard is discussed more fully in Chapter VI.

Symptoms of "flashed" eyes are a pronounced irritation under

[7] "Electrical Accidents and Their Causes, 1936," *Industrial Safety Survey*, XIV (May-June, 1938) 83-84.

the eyelids, a feeling of "sand in the eyes," which usually develops several hours after the exposure. This means that the symptoms frequently develop after the worker has left the plant, sometimes late at night, in places where no doctor is readily available. Ordinarily no permanent after-effects result from "flashed" eyes. There have, however, been cases of serious infection caused by "home-remedy" treatment of "flashed" eyes—infection which eventually led to blindness. The first-aid treatment is simple: a few drops of sterile oil or of a 10 percent solution of argyrol, and a light bandage, or opaque glasses. Complete rest of the eyes is important.

Part Two

THE SOLUTION

Chapter VI

ELIMINATING EYE HAZARDS BY MECHANICAL GUARDS

THE SUREST METHOD of preventing eye accidents is, of course, to eliminate the hazardous process, operation, or substance which may cause an accident. However, until greater progress has been made in applying process revision to accident prevention, the proper use of mechanical guards, goggles, and head masks remains unequalled as a means of preventing injuries to the eye.

Great strides have been made during each successive year in the development of such mechanical devices. Goggles and other forms of head and eye protection have been designed for every known type of eye hazard. Goggles have been adapted to fit the contours of the face and to meet almost every objection that might be voiced by workmen.

There are now scores of types and styles of goggles with which to solve the problem of guarding against industrial eye hazards, but this great multiplicity of types and styles of goggles itself presents a new danger: that of using the wrong goggles for a particular hazard.

The choice of goggles cannot safely be left to the workman or to the foreman. Even the safety engineer cannot properly select goggles without careful study. The exact nature of the particular eye hazard confronting a particular workman and the details of construction and materials of the various styles of goggles must

be carefully considered. The hazards of certain occupations can be guarded against only by the type of goggles developed for that particular hazard. Use of improper goggles may be as dangerous as failure to wear goggles at all.

GOGGLES OR GUARDS?

The safety engineer—or whoever else may have the responsibility for accident prevention—is faced with the further problem, whether to install guards in place of goggles. Some safety engineers of long experience maintain that glass or wire-screen guards on abrasive wheels, lathes, and drill machines which present serious eye hazards at the point of operation are useless because workmen take out the glass, push the guards aside, or remove them altogether. These authorities maintain further that guards are impractical because they get dirty and pitted from flying particles and that workmen then "look around them." Guards must be kept clean and pitted glass must be replaced frequently or they become useless.

Analysis of the experience of safety engineers representing both points of view on the much debated "guards versus goggles" question leads to the conclusion that mechanical guards and goggles should supplement each other. Neither affords complete protection all the time on all jobs; together they can do as efficient a job as is possible. It is important to remember, however, that mechanical guards of all types must be selected with care and serviced properly and that servicing—cleaning the glass and replacing cracked or pitted glass—must be the responsibility of appropriate and conscientious individuals if the guards are to be kept in good working order. The proper care of goggles and guards will be discussed in more detail later in this chapter.

CHOOSING THE PROPER MECHANICAL GUARDS AND GOGGLES

The first step in any effort to prevent industrial eye accidents by mechanical means should be the reading of *The American Standard Safety Code for the Protection of Heads, Eyes, and*

Respiratory Organs.[1] Next, the responsibility for selection and distribution of goggles should be placed on some one individual who is capable of applying intelligently the material in the *Code* to the special conditions in the individual plant.

The *Code* was developed by the United States Bureau of Standards, with the assistance of an advisory committee made up of the representatives of employers, employees, state industrial commissions, and the manufacturers of goggles and other safety equipment. The *Code* has been revised several times and approved by the American Standards Association. This approval is a guarantee that all the interests in any way involved in the subject of the code were represented in its preparation and revision.

Another valuable aid to anyone concerned with the prevention of industrial eye accidents is the "Safe Practices Series," particularly the pamphlet on goggles, published by the National Safety Council and revised in 1940. This publication contains material based upon the experience of a large number of varied industries which supplements and amplifies the basic standards of the *Code.*

In its "Safe Practices Series"[2] the National Safety Council groups goggles into five classes, according to the hazards against which they guard: *(a)* impact; *(b)* dust; *(c)* splash; *(d)* fumes or gases; and *(e)* glare and injurious light rays. Goggles for each of these groups of hazards have special characteristics. Protection against impact requires sturdy frames with hardened-glass lenses. Goggles for protection against dust should enclose the eye completely; ventilating holes or baffle slots are permissible in dust of certain composition. Goggles intended to provide protection against splashes must be made of a material impervious to corrosive chemicals or molten metal, depending upon the hazards involved. Protection against fumes and gases requires goggles completely enclosing the eyes and made of material impervious to corrosive substances. Goggles which are to protect the eyes from glare and harmful light rays must have colored lenses with special absorption and transmission qualities.

[1] United States Department of Commerce, Bureau of Standards, *American Standard Safety Code for Protection of Heads, Eyes, and Respiratory Organs.*

[2] National Safety Council, *Goggles.*

CLASSIFICATIONS OF HAZARDS IN NATIONAL CODE

The United States Department of Commerce, Bureau of Standards divides eye hazards and methods of guarding against them into nine classifications.[3] The first three classifications deal with flying particles, relatively large particles, small particles, and dust; the fourth group deals with the hazard of molten metal; the fifth, with toxic gases, fumes, and liquids; the sixth, seventh, and eighth groups deal with the hazards of radiant energy and of reflected light or glare; the ninth group deals with the hazards of abrasive blasting, a highly specialized process, the hazards and guards of which are not included in any other group.

Each of these nine groups requires protectors having distinctive features. Goggles which are effective in guarding against hazards of one type are often useless for hazards of another type. In the following paragraphs the nine types of hazards, as classified in the *Code,* will be discussed in relation to the processes and operations in which the hazards exist, the required specifications for goggles, face masks, and hoods to be used as protectors against these hazards, and any other type of mechanical guard which may be used supplementary to goggles. The examples given for each group are illustrative only and are not intended to be complete.

The groups as defined in the *Code*[4] are as follows:

Group A.—Processes where protection from relatively large flying objects is required.

Examples of these processes are chipping, calking, and some riveting operations and sledging in quarries.

Group B.—Processes where protection from dust and small flying particles is required.

Examples are scaling and grinding of metals, stone dressing where quartz is not involved, and some woodworking operations.

Group C.—Operations where protection from dust and wind is required.

Examples are automobile driving, airplane piloting in open cockpits, and electric spot and butt welding, where there is no exposure to radiant energy.

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[3] *American Standard Safety Code for the Protection of Heads, Eyes, and Respiratory Organs,* pp. 2-3.

[4] *Ibid.*

Group D.—Processes where protection from splashing metal is required.

Examples are babbitting, pouring of lead joints for cast-iron pipes, casting of hot metal, and dipping in hot metal baths.

Group E.—Processes where protection to the eyes from gases, fumes, and liquids is required.

Examples are handling of acids and caustics, dipping in galvanizing tanks and some japanning operations.

Group F.—Operations where protection is required from reflected light or glare.

Examples are long exposure to snow-covered ground, exposure to reflected sunlight from roofs, roadbeds, etc.

Group G.—Processes where protection from injurious radiant energy with a moderate reduction in intensity of the visible radiant energy is required.

Examples are oxy-acetylene and oxy-hydrogen welding and cutting; tending electric arc furnaces; open hearth, Bessemer, and crucible steel making; furnace work, electric resistance welding, brazing, and testing of lamps, involving exposure to excessive brightness.

Group H.—Processes where protection from injurious radiant energy with a large reduction of the visible radiant energy is required.

Examples are electric arc welding and cutting, irradiation with ultraviolet light, and hydrogen welding.

Group J.—Abrasive blasting.

The *American Standard Safety Code*[5] offers the following definitions of the principal forms of material protection:

Protector.—A protector is a device which is placed in front of or over the eyes, face, or head to afford protection from the hazards in industrial processes or from the natural elements.

Goggles.—Goggles are an optical device worn in front of the eyes, whose predominant function is protection to the eyes only.

Face Mask.—A face mask is a device worn before the eyes and a portion or all of the face, whose predominant function is protection to the eyes and face.

Helmet.—A helmet is a rigid device worn by the operator, which shields the eyes, face, neck, and a portion or all of the other parts of the head and is held in place by suitable means.

Hood.—A hood is a non-rigid device which completely covers the head, neck, and portions of the shoulders so as to exclude dust and flying particles.

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[5] *Ibid.*, p. 4.

Shield.—A shield is a device to be held in the hand, or supported without the aid of the operator, whose predominant function is protection to the eyes and face.

Goggles with corrective lenses vs. wearing goggles over spectacles.—Before discussing specific eye hazards, it may be well to clear up two matters concerning which there are wide differences of opinion among safety men. The more important of these two controversial subjects is the question of protecting the eyes of workmen with defective vision engaged in occupations requiring use of goggles. Practically all safety engineers agree that ordinary spectacles do not afford sufficient protection against accident hazards to justify their use in the place of goggles. There is, however, a difference of opinion as to whether workmen who need spectacles should be expected to wear goggles over their spectacles or should wear goggles with corrective lenses.

The commonly voiced objection to the latter is that ground, or prescription, goggle lenses, when broken, are more likely to fly out of their frames and into the eyes of the wearer than are unground, or stock, goggle lenses. This failing of ground lenses has been greatly reduced by modern methods of hardening glass. Although lenses which have been ground extremely thin are still dangerous, the average corrective lens, made of specially hardened glass, is not likely to fly out of the frame when broken. The most commonly voiced objections to the use of goggles over spectacles are: (1) the discomfort of wearing two frames; and (2) the fact that under such circumstances both spectacle lenses and goggle lenses cloud easily. To offset this difficulty modern methods of goggle construction have done much to overcome these objections. Since these objections are still valid to some extent, however, the slightly greater protection of goggles if worn with spectacles, together with the likelihood that they will not always be worn, should be weighed against the almost complete protection afforded by goggles with corrective lenses and the greater likelihood that they will be worn all the time.

An inquiry by the National Society for the Prevention of Blindness among a large number of safety engineers indicates that they

almost universally prefer goggles with corrective lenses except for the rare cases in which the workman himself prefers to wear goggles over his spectacles and in the relatively few cases in which the optical prescription requires grinding the goggle lens dangerously thin. In most cases, however, the slight loss of strength from grinding is more than compensated for by the convenience of wearing only one pair of goggles instead of goggles and spectacles. The 1938 edition of the *American Standard Safety Code*[6] suggests goggles worn over corrective spectacles and, as an alternative, goggles with protective lenses which are ground to provide the proper optical correction. The most important element in eye protection by means of goggles is getting the workmen to wear them; everything possible should be done, therefore, to make the wearing of goggles easy and convenient. If workmen cannot be persuaded to wear corrective lenses in goggles, most of their objections to wearing goggles over spectacles are overcome by the greatly improved lighter weight coverall goggles which have been developed in recent years.

Another alternative, recently developed, which seems to be proving satisfactory is the use of light-weight transparent face shields. These shields (which may be worn over corrective glasses) provide wide, unrestricted vision through cellulose acetate windows, which the manufacturers assert are noninflammable and resistent to small metal particles. Inasmuch as these face shields are extremely comfortable, they may provide a solution to the problem of eye protection in certain occupations. In general, however, safety engineers are not convinced of the efficacy of this type of eye protection. Cellulose acetate masks have been used so little in American industries that no substantial body of opinion as to their effectiveness has been developed. They have been widely used in British industries for a number of years with very good results, according to Joseph Minton, medical representative of the Industrial Eye Injuries Committee, Royal Eye Hospital, London, England.

The use of laminated lenses in goggles to avoid the danger of

[6] *Ibid.*, p. 55.

glass flying into the eyes of workmen from a goggle lens shattered by a flying object of great weight or force is another goggle question which has long been the subject of controversy. This controversy has ended in favor of non-laminated lenses. The chief objection to the use of laminated glass for goggle lenses is that they are poor transmitters of light, especially when exposed to high temperatures—as they are, for example, in frequent sterilization. British authorities, on the other hand, report unusual success in using goggles with laminated glass. Perhaps in the future refinements in the construction of laminated glass will produce a shatterproof lens with satisfactory transmissive powers. At present such goggles are generally considered unsatisfactory in this country; in fact, Federal goggle specifications do not permit laminated lenses.

PROTECTION AGAINST RELATIVELY LARGE FLYING OBJECTS

The danger of injury to the eye from relatively large flying objects, such as rivets, nails, metal chips, concrete chips, splinters of wood, and fragments from mushroomed tools, exists to some extent in practically every industry, but is most serious in certain operations of the metal industries, in quarrying, and in the construction industries—particularly in shipbuilding and structural steel work. When it is impossible in any specific operation to eliminate this hazard by changing the machine, the tool, or the method of work, protection must be sought through the use of goggles, masks, or screens, depending on local conditions—often by combining these three media.

The chief requirement of goggles to be used in guarding against large flying objects is strength—strength of frame, lens container, side shields, and lens. It is essential that lenses be made of the strongest clear glass available, that lens containers are made so as to prevent fragments of the lens from flying out under the force of a heavy impact, and that the frame and side shields are strong enough to withstand heavy blows.

Side shields are necessary in order that flying particles may not

enter the eye behind the lens. The shields may, of course, be solid or perforated, but if perforated the holes should not be large enough to allow particles to enter. The frames of goggles should be of light substantial material and should fit the face closely below the eyes. The principal requirements are comfort to the wearer and strength enough to serve their purpose. The latter requirement is determined by a strength test of the lens containers and the frames prescribed in the *American Standard Safety Code*.[7]

Transmission of a high percentage of light is important for this class of work. The *Code* specifies glass that transmits not less than 70 percent of the incident visible light. The Federal specifications for goggles for government employees and the goggle specifications of many industrial firms demand glass which will transmit not less than 89 percent of the incident visible light. These specifications of light transmission apply to all types of goggles except, of course, those designed to protect the eyes from glare and from harmful radiant energy; the colored lenses of such goggles transmit much smaller percentages of light.

Frames of goggles should have a smooth finish and should be of a material that will permit sterilization and that will not tarnish, rust, corrode, or otherwise react chemically to perspiration. Such a chemical reaction might irritate the skin.

Operations in which large flying particles are a hazard.—In the metal industries operations such as chipping, finishing, riveting, and metal-lathe work are extremely hazardous, because large, heavy fragments of metal may be sent flying in any direction with great force. In quarry work the hazard of large flying objects is present in every operation. In shipbuilding and ship-repair yards this hazard is present in nearly every operation in which pneumatic tools are used. These include riveting, caulking, chipping, drilling, and reaming. Many operations in general construction work present equally serious eye hazards—the driving of nails, stone drilling, metal and hardwood planing, and all forms of demolition work. The eye hazards in these operations will be discussed in more detail in the following sections.

[7] *Ibid.*, pp. 31-32.

FIGURE 12

CHIPPER WHOSE EYES ARE WELL PROTECTED BY GOGGLES

Chipping is a hazardous operation, but this man's eyes are well protected.

Hazards in the metal industries.—The chipping or finishing of iron and steel castings and forgings probably presents the greatest hazard from relatively large flying objects, both because of the great number of men engaged in such work and because of the nature of the wound usually caused by chips from steel castings. In practically every foundry there is a finishing or chipping department where rough spots, adhesions, and other defects are removed from the surface of the castings. When this work is done with powerful pneumatic chisels, fragments of steel sometimes fly through the air at bullet-like speed. Frequently chipping is also necessary in other metal-producing, metal-working, and metal-fabricating plants.

The dangers incident to the penetration of the eyeball by a fragment of steel, brass, or copper are serious—such injuries often resulting in infection and loss of sight. Flying chips may penetrate the eyeball so deeply as to lodge in the posterior part of the eye, from which removal is extremely difficult and sometimes impossible, even with the greatly improved surgical magnets now in use and the skilled technique of ophthalmologists who have specialized in industrial work.

In the steel industry an operation which has been one of the most frequent causes of such injuries is the removal of surface seams from cold steel blooms. In finishing cold steel blooms, chippers frequently work toward one another from opposite ends of the bloom, with the natural result that chips from each worker's chisel are directed into the face of the opposite worker.

In plants of progressive companies every effort is made to discover the safest position for each chipping operation and to train chippers to work in that position. In line with this practice, cold-steel-bloom chippers are instructed either to start from the middle of a bloom and work in opposite directions or to work in the same direction on separate blooms. For this operation suitable goggles eliminate practically all danger to each workman from chips from his own chisel, and the judicious use of floor screens minimizes the danger that he will be injured by the chips from the tools of other workmen. These screens may be made of a double layer

FIGURE 13

WORKMAN WHOSE SIGHT WAS SAVED BY GOGGLES

This man was knocked unconscious by a blow from a metal fragment against a lens of his goggles.

of substantial burlap or heavy canvas and should be mounted on frames which are adjustable as to height and easy to move. Wherever metal chipping is done such screens in various sizes should be available; their use should be considered as imperative as the wearing of goggles, but they should in no case supplant the goggles. An inexpensive but effective screen may be made of wall-board.

Safety engineers of long experience agree that goggles should

be worn in every chipping operation and that all other forms of protection should be considered supplementary. Liberal use of screens is recommended for chipping departments in which workmen from other departments, plant executives, or visitors may come within range of flying chips, even though such a possibility seems remote. In industrial plants in which the goggle-wearing rule is not strictly enforced for all visitors and transients, as well as for the chippers themselves, the eyes of many a passer-by have been injured. The elimination of this most serious eye hazard is in many plants a fortunate by-product of the use of the welder's torch for burning rough spots off cold steel blooms and large castings rather than the high-powered pneumatic chisels once used to chip off such rough spots.

Protection within the rolling mill.—In the rolling mill two classes of men need to be protected from the principal eye hazard —the shower of flying scale thrown off each bloom during the first few passes between the rolls or under the hammer. The first class is the "rollers," the men who operate the rolling machines and who stand on an elevation behind the rolls. Complete protection for these men may be secured by the construction of a plate-glass shield, preferably of wire glass, in front of the operator's platform. The second group of men who need to be protected from flying scale consists of the workmen who stand beside the rolls to pry loose blooms that have become wedged or otherwise unruly. In the past these men have been—and in some plants still are—protected from flying scale by masks made of fine mesh wire. To prevent eyestrain resulting from the poor vision through wire mesh, up-to-date wire masks are designed with a glass holder in which is inserted a plate of substantial case-hardened glass, thus giving complete protection and at the same time better vision.

The hazards of riveting and rivet removing.—The eye hazard inherent in reaming, riveting, and rivet removing in such occupations as building construction, shipbuilding, boiler making, car building, and dismantling of ships, cars, or structural steel work, is not so serious as the chipping hazard insofar as frequency is concerned, but it is perhaps more serious in terms of severity.

While this hazard also has been intensified by the use of powerful pneumatic tools, the fact that the increased efficiency of such tools has cut down the number of men needed is a compensation;

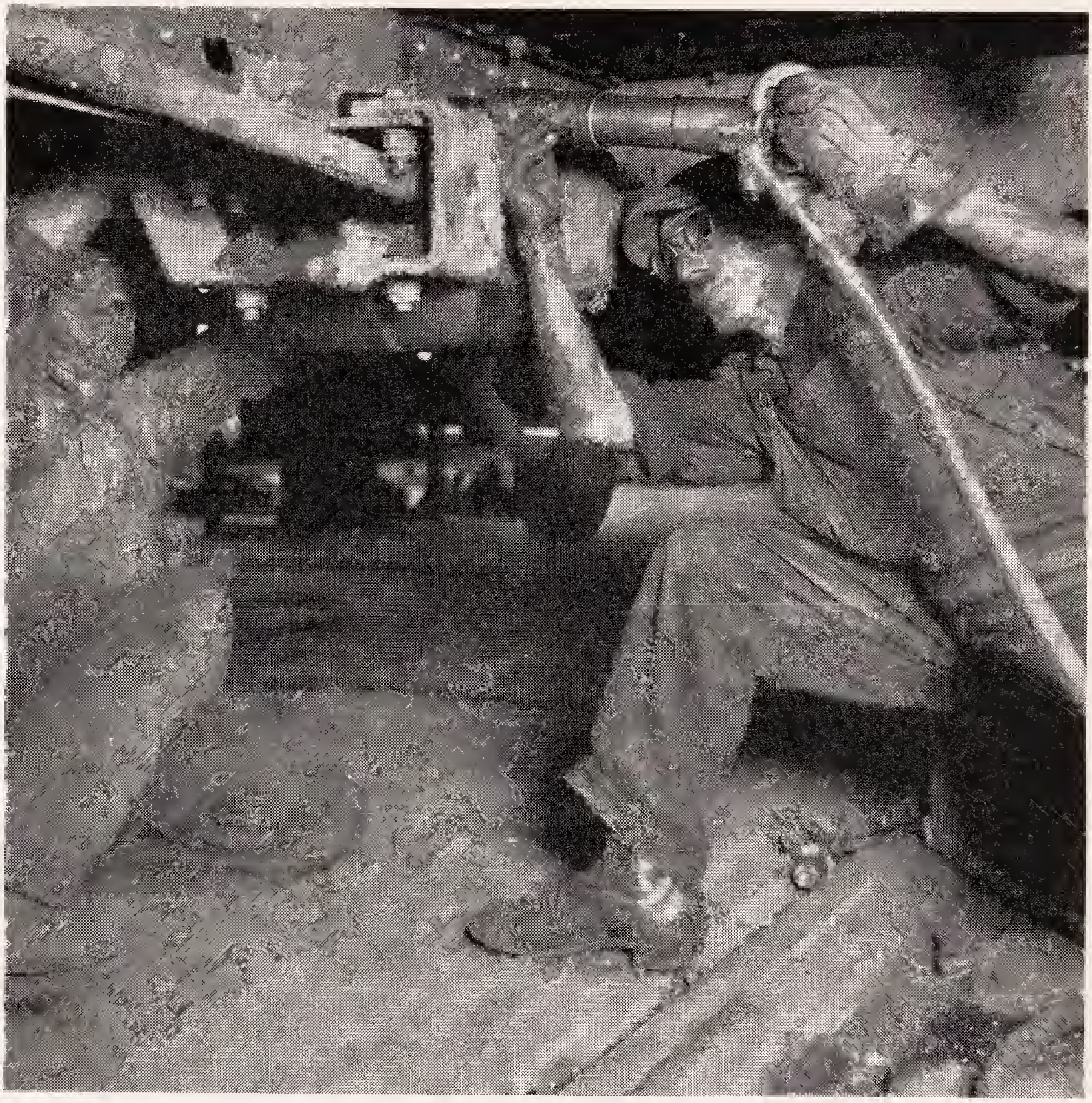

FIGURE 14

RIVETERS AT WORK UNDER A PULLMAN CAR

Note that these men are well protected by goggles.

like the automatic machine, it has proved to be a safety measure.

The valve in the air hammer occasionally sticks or breaks in riveting, and when the hammer is removed from the rivet the plunger may fly out of the tool and strike the bucker in the face. Recognizing this danger, many buckers take the precaution of

turning their faces sidewise, especially when the hammer man is driving upper-cut rivets. This is only partial protection; moreover, it interferes seriously with the efficiency of the operation. Much more effective for the prevention of this type of accident are the arresting devices with which modern pneumatic tools are equipped to hold the plunger in place when a defect in the valve develops or when the trigger is touched accidentally while the air is on.

Some buckers cover only part of the rivet head with the dolly-bar, expecting that the jarring of the hammer will bring the bar completely over the rivet head; this exposes them to considerable danger. The rivet head should always be entirely covered, for if it is not, the rivet may shoot the bucker if it jumps out of the hole when the force of the hammer is applied.

The cutting of rivet heads in breaking down boilers, steel cars, ship plates, or structural steel work is considered by many safety engineers to be more hazardous than the operation of riveting itself. In cutting off rivet heads with high-powered pneumatic chisels, the tremendous force applied often sends the rivet head flying through the air with great velocity, thereby endangering not only the rivet-cutting gang but also other workmen within a range of one hundred yards or more. It is frequently necessary for several groups of men to cut rivets while working in close proximity. Under such circumstances neither goggles nor ordinary head masks provide sufficient protection. There has been developed for this purpose in the plants of the Pullman Car Company and in the American Car and Foundry Company a mask similar to a baseball catcher's mask, except that there are no large openings for the eyes. This mask is made of substantial wire mesh, and the eyes are further protected by an inner mask of finer wire mesh. Here again, as in the case of wire masks used by workmen in rolling mills, a mask with a heavy glass insert in front of the eyes will reduce eyestrain without reducing the necessary protection.

In some plants a catcher, consisting of a wire basket attached to the end of a long handle and held by the cutter's helper, is

used to catch rivet heads. In many plants the old practice of using brooms for this purpose is still permitted. These means of prevention are very unreliable, and sooner or later they may result in serious accidents. They should therefore be abolished.

Eye hazards in metal-working machine operations.—Operations involving the cutting and turning of metals on machines produce flying chips which are the cause of many eye injuries. This danger must always be taken into account in the tooling of brass, cast iron, and high carbon steel. These metals, being hard and brittle, are likely to be the source of flying chips, particularly when tooled at high speeds. In the machining of rough castings there is also the danger that sand from the molds, having adhered to the metal, will be thrown into the eyes of nearby workmen or passers-by. This often proves as great a menace as flying chips of metal. Because machine tooling is usually precision work requiring close attention, it is particularly desirable to make every effort to eliminate the eye hazard at the source. This is often made possible by the use of a suitable guard at the point of operation. The designing and installation of such guards should not, however, be left to the workman—although his advice should be sought, if for no other reason than to encourage proper use of the guard after its installation. In some cases guards placed on or near machines by workmen themselves have caused, rather than eliminated, accidents. Most "safety conscious" concerns purchase their guards from accredited guard manufacturers. However, a competent safety engineer or master mechanic who can recognize the hazards involved in an operation and can apply intelligently his knowledge of mechanical methods of eye protection should be able to devise a satisfactory guard for any shaper, lathe, milling machine, drill, or other machine tool. The guard should be made of substantial material—usually sheet metal or plate glass—and carefully fitted to the machine in such a way as to intercept flying chips and yet not interfere with the normal operation of the machine.[8]

[8] The National Conservation Bureau, *Handbook of Industrial Safety Standards*, contains photographs and detailed descriptions of guards for machines in woodworking, metal working, paper and printing, leather working, laundry, food, textile, and rubber industries.

For many industrial machines and operations it is impossible to develop guards which will effectively stop all chips. In such cases the wearing of suitable goggles should be compulsory. In fact, all workmen in close proximity to a hazardous machine or operation—*whether or not it is guarded*—should wear goggles. A guard may afford the operator of a machine sufficient protection most of the time, but there are many circumstances in which guards are useless. Goggles provide the only complete protection against the unforeseen eye accident.

Goggles for quarry men.—The use of goggles is not so prevalent among quarry men as it should be. Consequently many abrasions as well as punctures of the eye occur in this industry, although the frequency of such accidents is usually not great in any individual plant. Since eye hazards are regarded as not among the most serious accident hazards in this industry, many workmen and supervisors do not give the subject of eye protection the consideration that it deserves.

PROTECTION AGAINST SMALL FLYING PARTICLES

Occupations such as scaling and grinding of metals, stone dressing, and some woodworking operations constantly present hazards of injury to the eye through irritation from or actual imbedding of minute flying particles. Casualty-insurance company records indicate that accidents resulting from the operation of emery wheels, grindstones, and other abrasive media still constitute one of the most serious—if not the most serious—of all eye accident hazards. This is undoubtedly due to the fact that grinding wheels are used in large numbers and for a great variety of purposes in many industries, and they are being continually introduced as substitutes for other machining tools, both for rough dressing and for the finishing of machined parts. The large number of accidents resulting from operation of abrasive wheels emphasizes the necessity for greater attention to three things: the condition of grinding apparatus, the methods of operation, and—most important of all—means of insuring the wearing of goggles at all

grinding operations not thoroughly guarded by shields or other protective equipment.

In order to offer protection against dust and small flying particles goggles must enclose the eye completely. However, they need not comply with any strength tests, inasmuch as small particles seldom travel with sufficient force to break the lens or frame. Ventilating holes or baffle slots are permissible if the particular operation is such that the particles are not likely to be small enough to enter such openings.

Abrasive Wheels.—Practically every factory uses one or more abrasive wheels. A copy of the *Safety Code for the Use, Care and Protection of Abrasive Wheels*[9] should be on every safety engineer's reference shelf and his guide to frequent check-ups of this group of hazards.

The eye hazards incident to emery grinding are threefold: (1) emery dust from the wheel itself; (2) fine particles from the metallic surface which is being ground; and (3) flying parts of an abrasive wheel broken or "exploding" while revolving at great speed. Goggles do not provide sufficient protection against the hazards of exploding wheels; safety lies largely in preventing such accidents, which are nearly always due to defective installation, poor maintenance, or improper use of the wheel. Fortunately the greatest hazards in connection with the use of abrasives, those of flying particles, can be entirely eliminated by the use of proper goggles.

Goggles used for scaling and grinding are not subjected to severe blows, for the particles which are thrown off in this work are usually small and do not strike with great force. Further, particles may come from a wide angle toward the line of sight, and for this reason it is desirable to use lenses of at least 1.5 inches (38 mm.) in the vertical diameter and 1.75 inches (44.5 mm.) in the horizontal diameter.

Ordinarily goggles for grinders need not be of the heavy type. The thickness of the lens should be based on the kind of grinding

[9] American Standards Association, *Safety Code for the Use, Care, and Protection of Abrasive Wheels.*

in which the workman is engaged. In permitting workmen to wear light-weight, thin-lens goggles, which are satisfactory for grinding, there is, however, this great danger: the grinder may have occasion to do a bit of chipping or some other work in which the hazard of relatively large flying objects exists, and he may rely on his grinding goggles for protection—as often happens—with disastrous results. Some larger industrial concerns are accordingly adopting the more substantial, somewhat heavier, dustproof goggles of the type usually worn by chippers and other workers exposed to large flying objects and are requiring the use of this type for all operations except where colored lenses or protection against splashing acid is necessary—thereby giving maximum protection to all workmen. The great advances in the design and construction of goggles justify this practice, because chippers' goggles are now lighter and more comfortable than the grinders' goggles of a decade ago.

Although exhaust systems, glass shields, and other modern protective methods have greatly reduced the eye hazards of grinding wheel operations, this work is still such a frequent source of eye injuries that the wearing of goggles in all grinding operations is now compulsory in all plants where a serious effort to eliminate accidents is being made.

Flying emery particles are white hot. When they strike the eyeball they are likely to burn their way into the tissues, making removal a very difficult problem. Although the great heat may cauterize the edges of the wound, there results an abrasion which makes it easy for harmful bacteria to enter and thus to initiate serious infection.

The amount of foreign matter screened from the eyes of grinding wheel operators and the high temperature of these particles when they are flying straight to the eye can be imagined, when it is realized that goggles which have been used only a few months by a grinder are speckled with emery fused to the lenses. These pitted glasses are an excellent indication of what would be the result upon the delicate surface of the eyes were not the protective goggles in constant use. The goggles shown in Figure 15 show how

vital is the need for proper maintenance of protective equipment —goggles or guards. In plants in which the proper procedure for servicing, repairing, and replacing goggles is followed, goggles would never become pitted and actually visual hazards. Goggles should be serviced or replaced long before they are so badly pitted if the vision of the workman is not to be impaired and his susceptibility to accidents greatly increased.

It is difficult to believe that a workman who has seen such a pair of goggles would ever attempt to use an emery wheel, even for a moment, without goggles if a clean comfortable pair were available; yet few plants have taken the trouble to post such a pair of pitted goggles on the safety bulletin board or in some other conspicuous place where every workman who ever has occasion to use an emery wheel could see them. The proper use of goggles in conjunction with glass shields, hoods, and exhaust systems has in many plants completely eliminated the danger of eye injuries in grinding operations.

Considerable prejudice against the use of glass shields on emery wheels has been developed among workmen and foremen in many plants. The principal objection voiced is that in grinding at wheels so equipped, often workmen do not watch the work being ground through the glass shield but look around the shield or move the shield to one side. The real cause of this prejudice in most cases is, not the shield itself, but either neglect in its up-keep or improper installation or both. It is unreasonable to expect workmen to look through a glass shield which has become densely pitted with fused emery particles or covered with a month's accumulation of dust. Where one emery wheel is used by a number of men, it is unreasonable to expect one workman voluntarily to take the trouble to clean the glass shield. Nor can the workman be expected to use a shield which is so installed as to make it difficult for him to hold in place the material to be ground.

Where definite provision for keeping glass shields clean has been made, and where the shields have been so installed as to give the grinder the room necessary for his work, they are consistently used by workmen, including workmen wearing goggles.

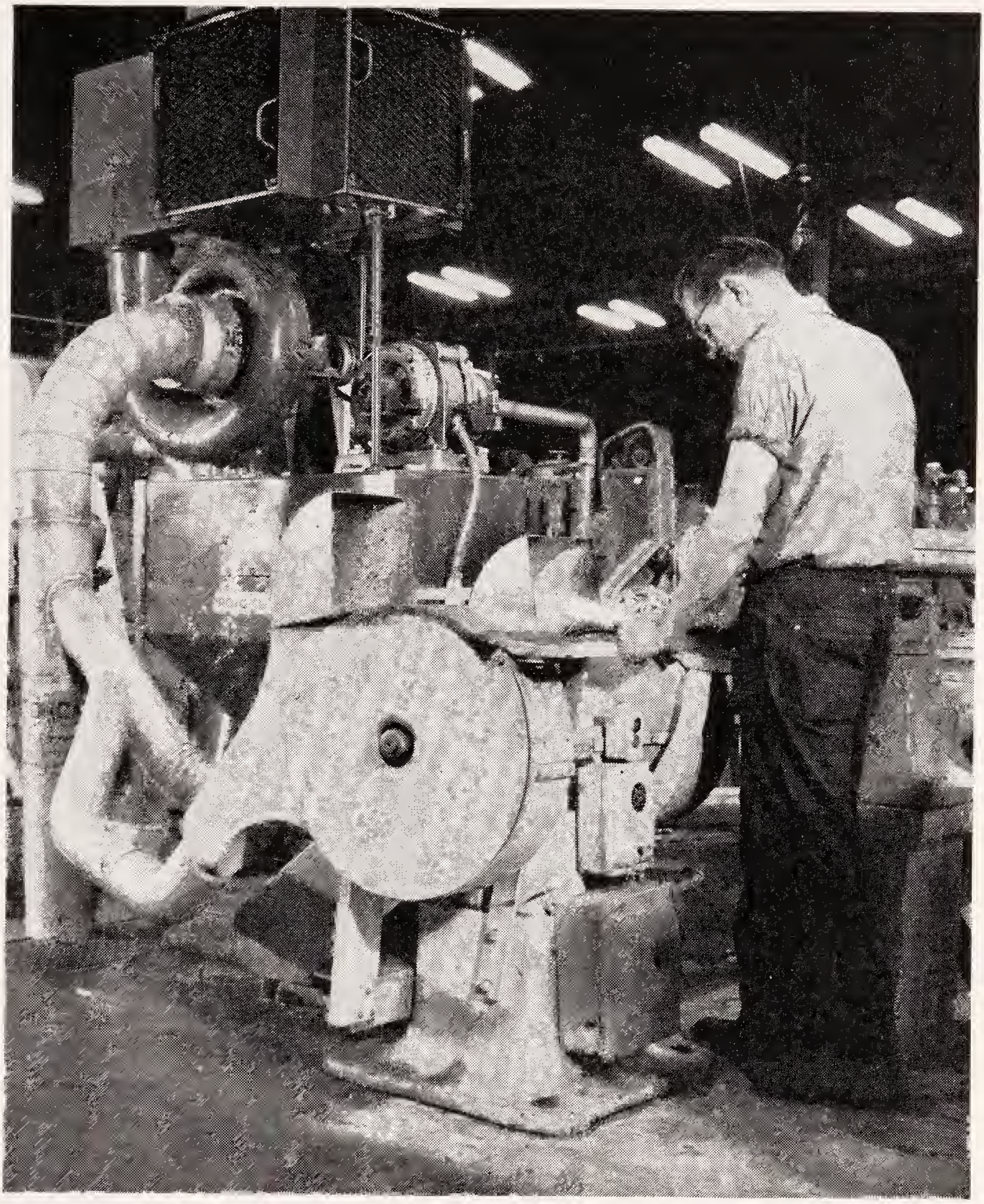

FIGURE 15

DOUBLE PROTECTION—GOGGLES ON THE MAN AND AN EXHAUST UNIT ON THE MACHINE

This employee is well protected from the sparks and dust particles given off by the emery wheel.

Where an emery wheel is used regularly by one workman the problem of maintenance may be solved by requiring each grinder to clean the glass shield on his own wheel at definite periods, preferably daily. Where a glass shield is installed on a wheel used by more than one man, or where the individual grinder cannot be relied upon to keep the glass shield clean, this responsibility should be placed on the shop cleaning force or on some particular maintenance worker. The definite placing of this responsibility, followed by frequent inspection, should insure the proper maintenance and the conscientious use of glass shields.

The frames of glass shields should be such as to make for easy replacement of broken or pitted glass. The cost of replacement may be reduced by using two layers of glass in the shield—a plate glass for the side nearest the workman and inexpensive ordinary window glass on the other side.

Installation of efficient exhaust systems involves considerably more expense than the installation of glass shields, but such systems nearly always pay for themselves over and over again in reduction of the compensation cost of eye injuries and in increased efficiency.

Where a glass shield is not in use, the workman should wear goggles notwithstanding the fact that the strong suction of an exhaust system may be pulling the stream of emery and metal particles away from him. The goggles protect the workman in the event of a momentary failure of the exhaust system or the bursting of the emery wheel. The wheel itself should be so guarded by a substantial hood extending well below the center of the wheel as to minimize the hazard to the workman in the event of an explosion of the wheel. This arrangement represents 100 percent safety in the operation of a machine, which in many plants is proving to be one of the most hazardous and most expensive causes of eye injuries.

Hoods are essential to the proper equipment of grinding wheels —not only to prevent the flying of broken parts in case of rupture but also to protect the eyes and lungs of the operators from dust. The hood should be substantially built and of design and strength

such that if a wheel breaks while revolving at great speed the parts will be retained by the hood. The wheels should be entirely contained within the hood, except for those portions which because of the nature of the work must unavoidably be exposed.

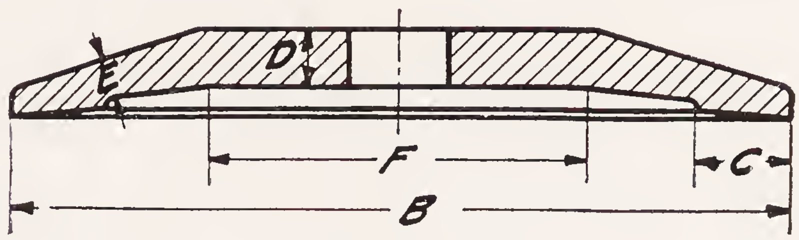

FIGURE 16

CROSS SECTION OF A DRIVING FLANGE

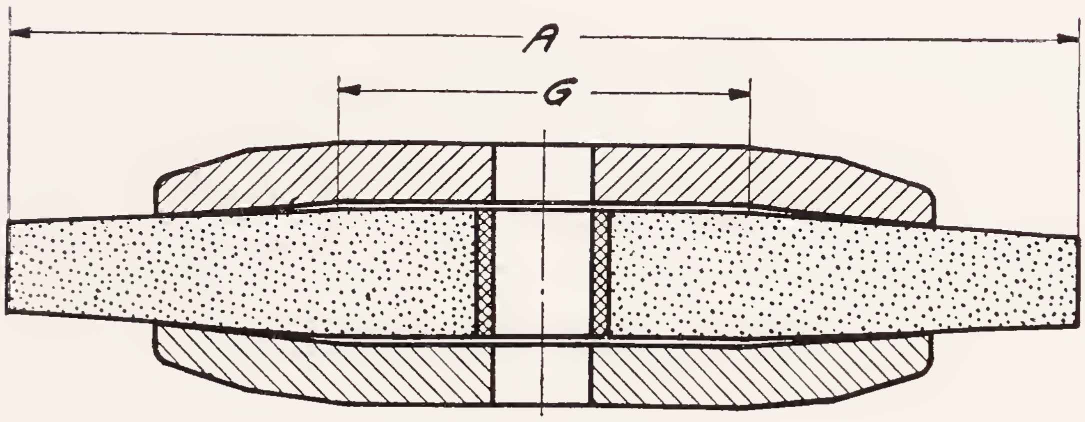

FIGURE 17

CROSS SECTION SHOWING DRIVING FLANGE SECURED TO SPINDLE

If it is impractical to equip the wheel with a hood, safety flanges must be used. These bind the wheel on either side and are suitable for either straight or tapered wheels. In the event of a ruptured wheel, the parts are clamped by the flanges. The entire surface, however, is not covered by the flanges, and for this reason the protection afforded is not so complete as that given by a hood. The use of both flanges and hood will give the maximum protection.

Flange requirements of American Standard Safety Code.—The general requirements for flanges in the *Safety Code for the Use, Care, and Protection of Abrasive Wheels*[10] are summarized as follows: All abrasive wheels shall be mounted between flanges, except those which are mounted in chucks, cemented to metal backs,

[10] *Ibid.*

or otherwise securely and adequately mounted on spindles. These flanges (sometimes called collars) may be of the straight type, the tapered type, or of some other design affording at least equal support and protection. All tapered flanges more than ten inches in

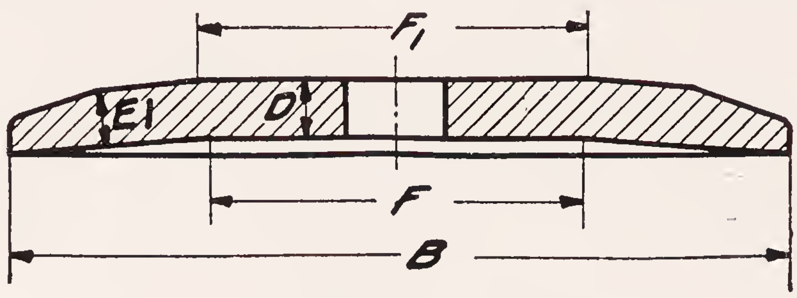

FIGURE 18

CROSS SECTION OF A TAPERED FLANGE

diameter shall be of steel. All other flanges may be of cast iron or other material of equal strength. Flanges shall be finished all over and correct as to dimensions and in balance. The requirement for balance does not apply to so-called balancing flanges, which are purposely made out of balance. Both flanges, whether straight or tapered, in contact with wheel shall be of the same diameter.

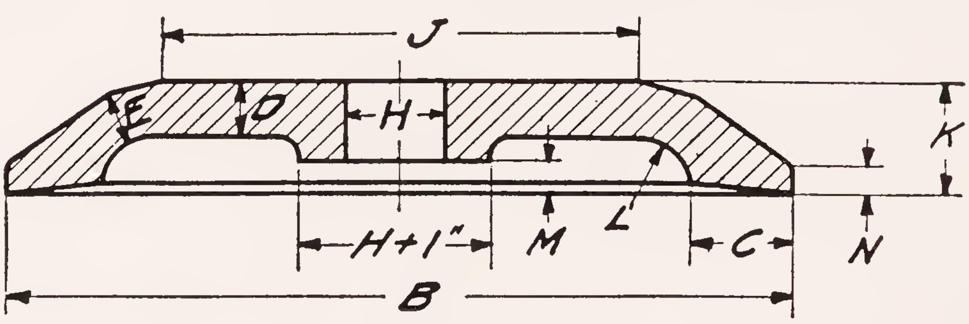

FIGURE 19

CROSS SECTION SHOWING TAPERED DRIVING FLANGE SECURED TO SPINDLE

Flanges, whether straight or tapered, shall be recessed at least one-sixteenth of an inch on the side next to the wheel for the distance specified in the respective tables of dimensions for straight and tapered flanges. Straight flanges of the adaptor and sleeve types shall be recessed so that there will be no bearing on the sides of the wheel within one-eighth of an inch of the hole. Bearing surfaces of flanges shall be so designed that when tightened up full contact with wheel will be insured. The driving flange shall

be keyed, screwed, shrunk, or pressed onto the spindle, and the bearing surface shall run true and at right angles with the spindle. Protection flanges (also called "safety collars") shall always be used with wheels six inches and larger which are not provided with protection hoods, chucks, or bands. Tapered flanges, or collars, made according to Fig. 16 and Fig. 19 shall have the same degree of taper as the wheels—that is, at least ¾ inch per foot on each side of the wheel. Tapered flanges or collars made according to Fig. 18 shall be tapered 1/32 inch per foot more than the taper of the wheel. When no hoods are used, the dimensions of tapered flanges or collars shall not be less than those shown in Table 10.

The *Safety Code for the Use, Care, and Protection of Abrasive Wheels* also contains recommendations for the use of protection hoods, bands, or chucks when protection flanges are not used.

Table 10

TAPERED FLANGE DIMENSIONS IN INCHES

A Dia. of Wheel	*B* Min. Outside Dia. of Flanges	*C* Radial Width of Bearing Surface Fig. 16 Only		*D* Min. Thick. of Flange at Bore	*E* Min. at Edge of Recess Fig. 16 only	*E₁* Min. Thick. at Bevel Fig. 18 only	*F* Max. Flat Spot at Center of Flange Inside	*F₁* Dia. of Flat Area Outside Fig. 18 only	*G* Max. Dia. of Flat Spot or Hub of Wh.
		Min.	Max.						
6	3	¼	½	⅜	3/16		0		1
8	4	5/16	⅝	⅜	¼		0		1
10	5	½	1	½	¼		0		2
12	6	½	1	⅝	5/16	½	4	5	4½
14	8	⅝	1¼	⅝	⅜	½	4	5	4½
16	10	¾	1½	⅝	⅜	½	4	6	6
18	12	1	2	¾	½	⅝	4	6	6
20	14	1¼	2½	¾	½	⅝	4	7	6
22	16	1⅜	2¾	¾	9/16	⅝	4	7	6
24	18	1½	3	¾	9/16	⅝	4	8	6
26	20	1½	3¼	¾	⅝	⅝	4	8	6
28	22	1¾	3¾	⅞	⅝	⅝	4	8	6
30	24	2	4	⅞	¾	¾	4	8	6
36	28	2	4	1	⅞		4		6

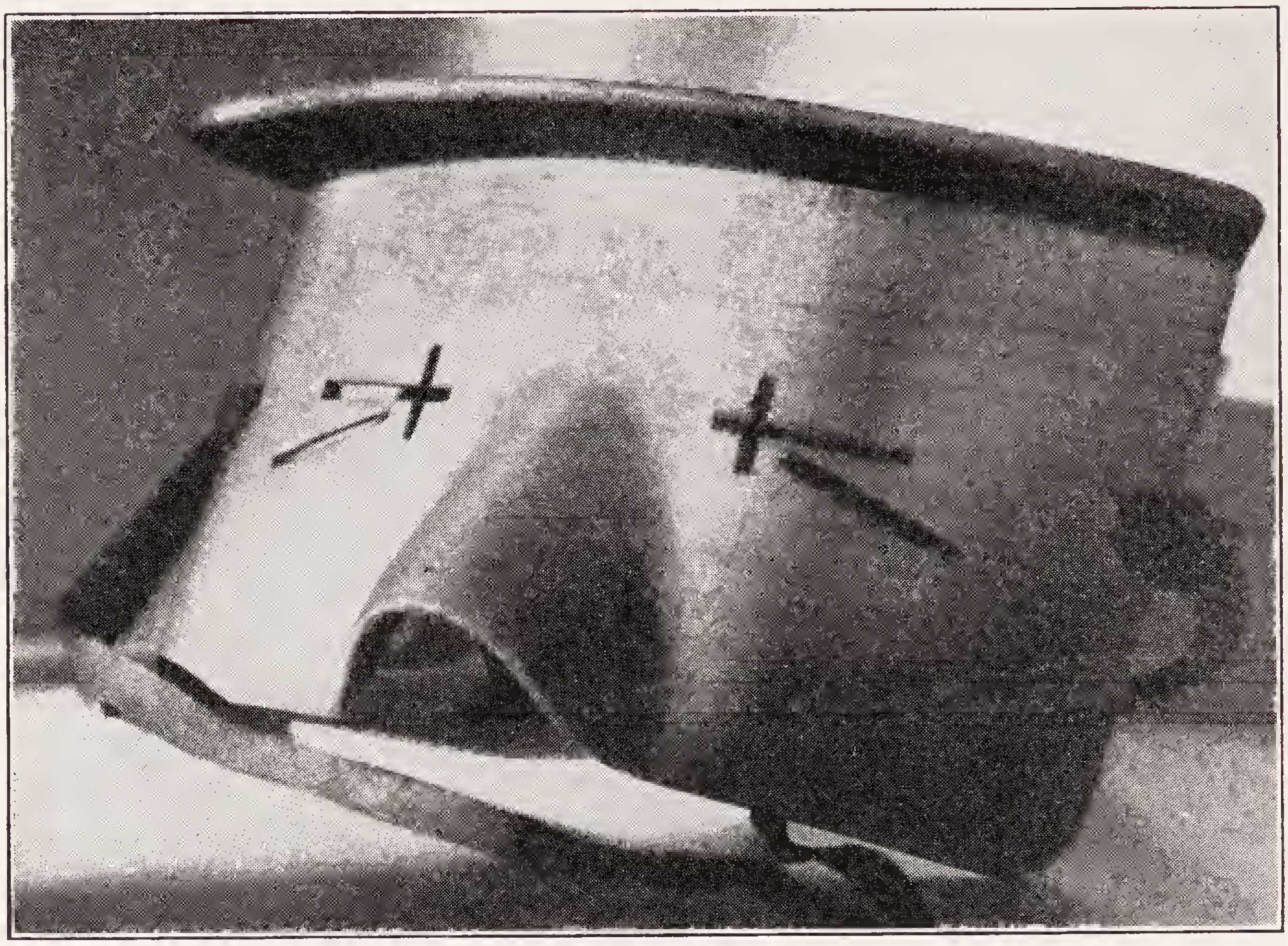

FIGURE 20

A WOODEN MODEL OF A WALRUS-HIDE EYE PROTECTOR

Such devices were used by the Eskimos as much as two hundred years ago as a protection against snow blindness.

The following suggestions concerning the safe use of emery wheels should, if observed, avert many of the accidents that frequently result in serious eye injuries:

Do not operate an emery wheel without protection for the eyes. Do not operate any emery wheel faster than the speed recommended by the manufacturer. Be sure that the speed is right before mounting wheel.

Be sure that the tool-rest on the emery wheel is not below the center of the wheel, and have the rest as close to the wheel as possible. An emery wheel should be running true and without vibrations. If it is not, call attention of the foreman and have the wheel fixed before operating.

Always keep bearings of grinders well supplied with oil. A hot arbor may expand and break the wheel.

Be sure that your wheel is running at normal speed before starting to grind.

One of the largest factors in the rupture of emery wheels is excessive speed. Carefully prepared tables of proper speeds for each size and type of emery wheel are contained in the *Safety Code for the Use, Care, and Protection of Abrasive Wheels.*

Dust and wind.—The hazard from exposure to dust and wind is great in only a few occupations, such as the driving and firing of locomotive engines with open cabs, airplane piloting in open cockpits, commercial-vehicle driving in rural districts and on dusty roads, roofing, and outdoor electric welding. Since this hazard, where it does exist, is so constant and obvious there is little difficulty in inducing the exposed workmen to wear goggles. The chief consideration in the selection of goggles should be comfort. Light-weight goggles which completely enclose the eyes are the most desirable. Because of the danger of particles of dust entering from the side, completely dustproof side shields are essential. Frequently the hazards of dust and wind are combined with the hazard of glare caused by the necessity of looking in the direction of the sun. A locomotive engineer or motor-truck driver whose train or truck is heading toward the sun is subjected to this hazard. In such cases the combined hazards may be guarded against by use of light-weight goggles with side shields and colored lenses. Workmen in construction industries and repair or maintenance men in large industrial plants who are required to work on roofs or in yards also are exposed to the hazards of dust and wind.

Sand blasts.—Excessive dust and small flying particles occur principally in sand-blasting operations. Progressive plants now use sand-blast cabinets so arranged that the operator directs the nozzle of the sand-blast hose on the material to be cleaned through small dustproof openings and watches the progress of the work through a glass shield or window in the cabinet wall. Such cabinets provide complete protection for the eyes of the operator. When the worker is exposed to the sand, shot, or other abrasive used in such operations nothing less than a hood which completely covers the head and which fits snugly around the neck is suitable. The hood should be so designed that the operator is able to see his work without eyestrain.

Sand-blast operations are required for cleaning metal castings and stone surfaces of buildings, for removal of paint from railway cars, and for numerous other industrial purposes. In this operation also there is frequently opportunity for the elimination of accident and health hazards by means of engineering revision rather than by the use of hoods, goggles, or respirators.

Substitution of tumbling mills for the old method of hand scrubbing of castings is a good example of the elimination of this hazard by engineering. Many castings, however, are too large to be put into tumbling mills, and the fragility and fine surfaces of others make sand-blasting necessary.

Sand blasters sometimes attempt to use home-made helmets or other protective equipment of their own design. This should not be permitted except when the device has been carefully examined and approved by a competent safety engineer.

PROTECTION AGAINST SPLASHING METAL

In terms of severity and frequency the danger of injury to the eye from splashing molten metal is one of the most serious of all industrial eye hazards. This hazard is not confined to the metal-producing industries—although it is most severe there—but confronts employees of all other industrial concerns where babbitting, soldering, or pouring of lead or other molten metal is necessary.

The nature of the operation largely determines what style of protector—goggles, face mask, helmet, shield, or hood—should be used. If there is any possibility of the presence of water or moisture in the casting of any hot metal, the danger of the exploding of the molten metal is great and protection for the entire face as well as for the eyes is needed. In such cases it is desirable to use a substantial type of hood. Some device, giving at least the degree of protection afforded by goggles, should be used to protect the eyes from splashing metals in all other cases of babbitting, soldering, or pouring of liquid metal.

The United States Department of Commerce *American Stand-*

ard Safety Code for Protection of Heads, Eyes and Respiratory Organs does not restrict the kind of material or the designs to be used for face masks intended for protection from this group of hazards.

Concerning the specifications for frames of goggles used in these processes, the *Code* points out that tests conducted by the United States Bureau of Standards and by the manufacturers of protective equipment demonstrate that the principal cause for the failure of goggles in these processes is the heat of the molten metal which strikes the goggles, not the impact of the explosion.

The test consisted of dropping molten lead from different heights onto a number of lenses of different makes. It was found that in no case was the goggle frame injured, the only damage being the cracking of the lens. The design of the lens container should be such that in case a lens cracks the fragments will remain in position in the goggle frame.

The molten-metal-drop test, which was applied to a large number of goggles, showed that in the case of the lenses also the heat of the metal, not the impact, is the important element to be guarded against. It was found that for glass of a given make the thickness of the lens determines to some extent the resistance to cracking when molten metal is poured on the surface of the lens.

It was therefore concluded that protection will be afforded by a lens that will withstand a moderate blow of molten metal and a lens container that will retain a cracked lens in position. The former is assured by using .079 inch (or 2 mm.) as the minimum for the thickness of the lens. The need of unimpaired vision in the pouring of molten metal is apparent. This is the reason for specifying the transmission of 70 percent of light. Almost any lens made of so-called colorless glass will transmit 70 percent of incident light.

Since the danger of burns from the explosion or splashing of molten metal in the iron and steel manufacturing industries, and in foundries and furnace rooms in general, is usually accompanied by the danger of injury to the eye from exposure to intense light and heat, the goggles, masks, or other protectors used in

such operations are nearly always designed to afford simultaneous protection against both hazards. In the iron and steel industry most furnace men and workmen engaged in tapping, pouring, and casting are exposed to all these hazards. The danger presented by radiated heat in these occupations and the means of guarding against it will be discussed later.

One of the principal difficulties in inducing men who work in close proximity to furnaces in the metal industries to wear goggles is the fact that the ordinary discomfort of goggles is greatly intensified by their retention of heat, especially so in the case of goggles with all-metal frames. This condition may be alleviated by the use of goggles with strong vulcanized fiber or plastic frames or by covering the parts of metal frames which come in contact with the face with a nonconducting material, such as rubber tubing or leather, or better still, by the use of a mask rather than goggles.

Notwithstanding the very great and obvious hazard to the eyes from splashing metals, there are still plants where men work with molten metals without any eye protection. The excuse usually offered by such men is that the goggles "steam up," interfering with vision, and that the goggles become a menace because they "prevent a man seeing where to run in the case of an accident when his life may depend on a quick get-away." There is very little justification for these excuses today.

Modern goggles are so designed and constructed as to minimize the clouding of lenses, and practically all types of goggles for foundry work are constructed with rows of small holes on the side shields which insure a current of air close to the lenses. Even in plants in which less modern types of goggles are in use, clouding or steaming of goggle lenses can be prevented by applying a thin film of glycerine or clear white soap to the lens. A sweatband on the forehead to absorb moisture and prevent perspiration from running into the eyes also helps to relieve this difficulty. Sweatbands can be made economically from cheesecloth, various other absorbent textiles, and sponge rubber.

While eye protection in the foundry is nearly always thought

of first of all in terms of goggles and masks, there is great opportunity for reducing accidents by general improvements in the plant—such as proper lighting and ventilation—and by revising methods of operation. For instance, serious accidents may result from the spattering of molten metal when filling and emptying ladles. To avoid this, when filling from a continuous stream of metal the worker should cut into the stream from the front rather than from the back. Also ladle lips should be so designed that a smooth flow in a concentrated stream is secured.

Explosions are caused by the contact of molten metal with moisture in a ladle. Thorough drying of ladles will prevent such occurrences. Large ladles are frequently dried in core ovens; this prevents fouling of the foundry air by smoke—a result which would occur if the drying were accomplished by having fires built in the ladles or if an attempt were made to dry large ladles on a heater intended for the drying of small single-hand ladles.

When the lining and the drying of ladles are under the control of one man a better opportunity is afforded to inspect all ladles thoroughly every day. Responsibility for inspection for cracked or thin bowls, loose rivets, eroded shanks, defective welds, imperfect balancing, as well as daily attention to safeguarding the gear mechanism also should be concentrated in one or two assigned individuals. The foreman can give better supervision to this work if one man is delegated to the task. This method also tends to insure storage of ladles in a dry place rather than in damp corners or on wet sand, where they are likely to rust. Large ladles which remain unused for long periods of time should be stored on supports in order to provide sufficient air space around them and to prevent absorption of moisture from the ground.

Not only must dampness and moisture be avoided in ladles, but likewise in crucibles and molds. If crucibles contain moisture when exposed to high temperatures, there is rapid evaporation of the moisture into steam, which causes explosions. The storing of crucibles in dry, heated places when they are not in service and the avoidance of exposing to dampness the fuel used in storage ovens or melting furnaces will reduce the chances of accidents.

PROTECTION AGAINST GASES, FUMES AND LIQUIDS

The operations in which protection must be provided against this group of hazards are found in every industry. The long list of industrial poisons which may seriously affect the eyes, together with the list of operations in which these poisons are used, will give the reader an idea of the seriousness of gas, fumes, and liquids as eye hazards, and at the same time it will help the reader to determine where in a particular plant this hazard exists. The danger of injury to the eye from this group of hazards is most serious in industries such as the manufacture of storage batteries, soap manufacturing, aniline dye manufacturing, and in such processes in other industries as call for acid baths, bright dips, and metal plating. In these operations there is almost continuous use of acids and other dangerous chemicals.[11]

Goggles for protection against gases, fumes, and liquids must completely enclose the eye and must be impervious to corrosive chemicals. Where the exposure is primarily to corrosive liquids which may injure the face as well as the eyes, masks or hoods rather than goggles are recommended. It is also recommended that goggle frames and lenses used for protection against these hazards comply with the specifications required of goggles used for protection against molten metal, because acids, alkalies, and other corrosive chemicals are often used at high temperatures. It is sometimes advisable that eye protective equipment for these hazards be made of a material other than glass—as for example, cellulose acetate or mica, when the chemicals used might affect glass. Hydrofluoric acid, for example, is used for etching and frosting glass.

Sulphuric acid.—The danger of burning the eye with sulphuric acid in the manufacture of electric storage batteries is generally recognized and guarded against in that industry. This hazard is not so well known and consequently is not adequately guarded against by private car owners and mechanics working on automo-

[11] See Appendix II.

bile batteries in garages. Serious sulphuric acid burns of the eyes among automobile mechanics frequently result from improper handling of batteries.

As a help to understanding how these accidents may occur, a brief description of storage batteries is here given. The battery consists of an acid-proof cell containing lead plates pasted with lead oxides and filled with diluted sulphuric acid. There are several vents in the acid-proof cover—two closed by the usual electrode connections, while the others, which are for ventilation, are usually closed by rubber screwcaps having a pinhole aperture. Such a battery is continually charging or discharging unless it is completely inert. During the process of charging, heat and hydrogen are generated. When the battery is at an electrically low ebb, very small amounts of heat and hydrogen are given off, while a fully charged battery may have a temperature as high as 284° F. The hydrogen at this point shows as bubbles in the battery solution, and an open flame of any sort—an electric spark, a blow-torch, or a cigarette—may ignite the hydrogen which has been mixed with air, in an almost instantaneous flame. There would be no danger if these gases were unconfined, but as the flame occurs within the small air chamber in the cell, it may cause an explosion and the burning gases and sulphuric acid which lie near the surface may be driven through the ventilation aperture.

The force with which the mixture is expelled from the cell depends upon the amount of hydrogen present, but the hot sulphuric acid may be driven several feet into the air. If the space between the cell cover and the surface of the acid is such as to leave a large dead space for the accumulation of hydrogen, the force of the explosion may blow the cell cover off, spattering the acid in all directions. Prevention of such battery burns is simple; protective goggles should be worn by every mechanic who works with charging batteries.

The type of protector to be used by those who handle acids, caustics, fumes, and other corrosive or poisonous chemicals should be determined to a great extent by the nature of the process to be performed. The operations are so varied that it is

not deemed advisable to specify in detail what type should be used; judgment and experience must determine this.

Caustic soda.—Perhaps the most concise statement of what constitutes safety in the handling of caustic soda is that contained in *Industrial Data Sheet D-Chem.* 2. prepared by the National Safety Council. This statement, presented here in full, applies in general to the handling of most corrosive chemicals.

Handling Caustic Soda

Problem

1. What are the hazards in handling caustic soda and what precautions should be taken?

Hazards

2. Caustic Soda is the most dangerous of all alkalis to handle for it quickly attacks the flesh and eyes and is deadly if swallowed.
3. Burns by caustic soda are generally due to:
   a) Dripping and splashing.
   b) Mists or sprays.
   c) Flying particles and dust.

Discussion

4. Burns because of dripping and splashing are caused by:
   a) Leaking pipe lines, pumps, and tanks.
   b) Disconnecting pipe lines or other equipment in making repairs.
   c) Overflowing tanks.
   d) Splashing when liquor enters tanks, pots, and drums.
   e) Handling filled drums before molten caustic has solidified.
   f) Releasing air from a caustic blow case.
   g) Insufficient water in tank when using caustic cakes to make concentrated solutions.
5. Burns because of mists or sprays are usually caused by:
   a) Boiling liquor.
6. Burns because of flying particles and dust are usually caused by:
   a) Breaking solidified caustic for samples.
   b) Sweeping and washing floors.

c) Liquid caustic collecting on apparatus, solidifying, and dropping off.

d) Grinding and flaking solid caustic.

7. The dripping and splashing hazard may be eliminated as follows:

A. Leaking pipe lines, pumps, tanks:

a) Pipe lines should be made up with companion-flanged joints (not flanged unions) and with gaskets of caustic-resistant material fitting inside of bolt circles.

b) Flanges should be screwed on clean threads without use of joint compound. For high-pressure lines, extra heavy pipe and steel flanges should be used with pipe ends peened inside of flanges. Preferably the flanges should be welded to the pipe.

c) Pipe lines should be washed out occasionally to remove crystallized salt and caustic which accumulate and are liable to cause excessive pressure.

d) Caustic pumps should be of vertical submerged type wherever possible to avoid use of stuffing boxes.

e) Apparatus such as evaporators, used in handling liquid caustic under pressure should be tested periodically with cold water and under a somewhat greater pressure than that to which it is ordinarily subjected in order to detect leaks.

B. Disconnecting pipe lines or other equipment in making repairs:

a) In disconnecting pipe lines or other equipment workmen should operate from above their work whenever it is possible. They should be sure that there is no pressure on the line and that the line has been thoroughly drained before breaking flanges. Where possible rinse the pipe out with clean water.

b) The valve which controls the line should be closed and a "man-at-work" sign hung upon it until the repairs are completed.

c) Repair men working on caustic lines or equipment should be provided with a pail of clean water, near at hand, for instant use in case the caustic soda gets on a man's clothing or flesh. (See also paragraphs 11 to 13.)

C. Overflowing tanks:

a) Tanks must necessarily be provided with large overflow openings near the top. Such openings should be provided with baffle plates installed in such a manner as to prevent floating material from obstructing them.

b) Open-top tanks should also be provided with troughs attached to the outside, near the top, and in such a manner that in case a tank overflows, the liquid will be conveyed to an opening away from passageways and locations where workmen are liable to be.

D. Splashing when liquor enters tanks, pots, and drums:

a) Containers into which hot caustic is to be run should be absolutely dry and free of acid in order to guard against explosions.

b) Extreme caution on the part of workmen must be exercised to prevent splashing when liquor is entering containers.

E. Handling filled drums before molten caustic has solidified:

a) Filled drums, handled on trucks, should be covered to prevent danger of splashing.

b) Flat trucks operated by hand, should be provided with long handles.

c) Where tracks are not provided for the trucks, the roadways should be smooth.

F. Releasing air from a caustic blow case:

a) Where blow cases are used for handling caustic solution, proper care should be given the equipment and periodic inspection made of the blow cases, pipe lines, air lines, etc.

b) The air release line for venting a blow case should point neither upward nor horizontally, but should point straight down with the end of the line close to the ground. It is even better to discharge the release line into a small pit connected with the sewer system.

G. Insufficient water in tank when using caustic cakes to make concentrated caustic solutions.

a) If there is insufficient water in the tank, the reaction which takes place may cause the solution to spurt out of the tank.

8. The hazard of mists or sprays from pots containing boiling caustic liquid may be largely prevented by providing hoods over the pots to carry off the mists or sprays.

9. The hazard of flying particles and dust may be eliminated as follows:

   A. Breaking solidified caustic:

      a) Many consumers use large hammers on the iron drums and break the contents while still in the container. After this the containers are opened and the pieces handled with a shovel.

      b) In breaking up large pieces of solidified caustic by hand the pieces should be contained in, or covered with a soft material (such as burlap) to prevent pieces from flying.

   B. Sweeping and washing floors:

      a) Floors should be washed rather than swept, to avoid flying dust. The washing should always be done with a hose stream. All cleaning should be done at a time when the fewest people are working in the building.

   C. Liquid caustic collection on apparatus, solidifying, and dropping off:

      a) Liquid caustic will collect on apparatus from mists or sprays, from splashing, and from leaks and will solidify and drop off. To prevent this all apparatus should be kept as clean as possible and any liquid caustic thereon removed by washing.

   D. Grinding and flaking solid caustic:

      a) Grinding and flaking of solid caustic should take place in a special room for the purpose, remote from other operations, and the least possible number of men should be employed at the process.

      b) Each man in the grinding room should be equipped with a loose-fitting hood covering the entire head and neck.

      c) The floors, walls, and apparatus in the grinding room should be washed off with a hose after each day's grinding. Hot water is preferable for removing solidified caustic.

Protective Clothing

10. The hazard of caustic burns can be decreased if men wear protective clothing.

  a) Cotton clothing will withstand the action of caustic soda better than wool, and trousers and shirts of cotton should be used entirely. However, as an added precaution it is well to wear rubber aprons.

  b) The wearing of wide-brimmed hats will tend to protect the head and neck.

  c) Caustic soda rapidly eats leather. For that reason rubber shoes or boots should be worn instead of those of leather, and heavy rubber gloves used rather than leather ones. If leather shoes with wooden soles are used, puttees should be worn to protect the shoe tops and toes.

  d) Trousers should be worn with the bottoms of the legs outside of boots or shoes.

  e) Shirts should have long sleeves and should fasten tightly about the neck.

  f) Men handling caustic soda should wear suitable respirators or protective hoods.

  g) Suitable goggles should be worn.

Treatment of Burns

11. Should caustic soda in liquid form be spilled on a man's clothing, the clothing at this point should be immediately cut away and cold water instantly applied in liberal quantities.

12. Should caustic soda, solid or liquid, come into contact with the flesh or eyes, the injured part should at once be flushed with plenty of clean water. A plentiful supply of fresh clean water should always be readily accessible. Some plants use a 2 percent solution of acetic acid to neutralize caustic burns of the flesh and ½ of 1 percent solution of acetic acid for burns of the eyes after they have been thoroughly flushed with clean water. Others use a 10 percent solution of ammonium chloride for body burns and a 1 percent solution for eye burns after the water application.

Others, after the water application, use a 2 percent zinc sulphate solution for body burns and 1 percent zinc sulphate solution for eye burns.

13. After flushing with water and chemical neutralization, expert medical attention should be provided promptly.[12]

Shipping and storage of liquid chemicals.—This subject is well presented by the National Safety Council, as follows:

Acids are usually shipped or stored in one of four ways: tank cars, metal drums, boxed carboys, or small jugs or bottles in wooden boxes. When a new shipment of liquid chemicals is received, it is well to relieve any internal pressure which may have developed. Workers who do this should exercise care to avoid burns in case the internal pressure causes the liquid to spurt out. Small containers should not be exposed to the direct rays of the sun for any great length of time; it is best to store them in a cool place. Except when the contents are being drawn, containers should be tightly closed to prevent fume leakage and corrosive action by the chemical on the container.[13]

Tanks and vats.—The National Safety Council is also responsible for an adequate discussion of this problem, presented herewith:

Acid storage tanks should be placed on concrete foundations and arranged to permit access for complete inspection. The liquid is usually moved to various points in the plant through pipe-lines and centrifugal pumps. All acid-pipe-lines, joints, valves, connections, tanks, and other containers should be regularly inspected and leaks should be repaired at once. In some companies all acid valves are fitted with sheet metal shields. Before starting a repair job, the acid valves (and air valves, if air is used) should be closed and locked, the pipe or container drained, and sufficient time given to allow all gas to escape. In some cases, especially if a cutting or welding torch is to be used, the pipe or container should be thoroughly washed with a neutralizing alkali before the repair job is started. Otherwise the flame

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[12] National Safety Council, "Handling Caustic Soda," *Industrial Data Sheet D-Chem. 2.*

[13] National Safety Council, *Acids and Caustics,* p. 5.

may cause an explosion. In opening an acid line the above directions should be followed and then a lead shield laid over the flanges to protect the operator in case the acid spurts. The two bottom bolts of the flanges are removed and the remaining bolts loosened gently until the acid starts to drip. If the flanges do not part readily, use a small wedge which may be made from a forty-penny wire spike ground to a chisel point. The lead shield has a hole large enough to admit the wedge. When air is used to force chemicals out of containers, the air line should be equipped with a pressure gage, a pressure reducing valve, and a safety valve set to blow off at a pressure under the safe maximum working pressure of the container.

Every tank that is used for the storage of chemicals should be so installed as to minimize the danger in case the tank should rupture and the contents escape. The tank should be supported in such a way that leakage from any part of it would be noticed immediately, and it should be covered, externally, with a suitable protective paint that will prevent corrosion from moisture, fumes and other causes. It is also wise to surround the tank with a pit, catch basin or depression of some kind, large enough to hold the entire contents of the tank in case of rupture. This will not prevent the formation of fumes but will at least localize the liquid and prevent it from flowing into workrooms and other places where it would be dangerous.

Several companies have called attention to the need for providing overflow pipes for tanks that are used to store liquid acids and caustics. In some plants a flow indicator is installed in each overflow line and so arranged that it automatically shuts off the pump as soon as any liquid starts to overflow.

All open tanks or vats should be installed in such a way as will insure employees from falling into them. It is advisable to build the top of each vat to a height not less than 30 inches from the floor or standing level; otherwise a double handrail, at least 30 inches high, and (if top of tank or vat is flush with or below the level of the floor) a six-inch toeboard should surround such a vat. Walkways should not cross over open vats or tanks, but where their construction is absolutely necessary, they should be equipped with substantial handrails and toeboards. All handrails and toeboards should be inspected at regular and frequent intervals to make sure that nails and other parts have not been weakened by exposure to chemicals or to chemical fumes.

The manufacturers of liquid chemicals specifically warn their customers not to use compressed air in emptying acid containers, especially carboys and metal drums. Before filling, the containers are usually tested, but this test is for leakage only, and they are likely to burst if subjected to air pressure for operation purposes.

After a tank or vat has been emptied it is not sufficient merely to wash it out with water. To remove fumes and remaining particles of acid the container, after being washed thoroughly with plenty of water, should be cleansed further with steam introduced under considerable pressure by means of a hose. The hose should be directed against every part of the surface of the tank just as though the metal were being washed with a stream of water. Care should be exercised in handling a steam hose to prevent the scalding of operators and fellow-workers.

Some companies prefer to wash out acid containers first with water and then with a neutralizing alkaline solution. In using this method remember to give the container a final washing with water.[14]

Drums.—From the same source is the following discussion of drums.

Drums of steel, chrome nickel, aluminum, and steel drums with lead and rubber linings of size up to 110 gallons are used for transporting up to 1800 pounds net weight of chemicals. It is recommended that the gross weight of any of these packages be limited to approximately 1000 pounds, and in many instances this would limit the size to 55 gallons. They are best handled by rolling on the hoops. They should be emptied by gravity or siphoned and never by use of pressure.

Carboys are generally glass or earthenware bottles or jugs of 5 to 13 gallons capacity. They weigh from 80 to 270 pounds gross when filled. They should be encased singly in wooden boxes complying with specifications 1A or 1C as prescribed by the Interstate Commerce Commission. They should be carefully cushioned to prevent breakage. Excelsior and similar substances should not be used if the carboy contains nitric acid. Closures should be porous, earthenware or vented glass stoppers held in place preferably by suitable wires. Containers of similar capacity made of lead are also classed as carboys; cushioning is not required; stoppers should be of rubber or lead carefully secured to prevent leakage. Maintenance of these packages in good condition is essential to safety.

The bottom or sides of the box may give way suddenly, due to the corrosion of the nails or weakening of the wood by acid. Some acid manufacturers now use wood preservative and special nails which they claim prolong the life of their boxes from 200 to 300 percent. To prevent unnecessary corrosion carboys should not be stored in damp places or in open yards exposed to the weather. It is advisable to use a separate storeroom or building, the walls and floors of which are made

[14] *Ibid.*, p. 6.

of silicate-treated concrete or brick, properly drained to the sewer or to a catch basin.

Boxed carboys when placed on the floor should rest on wooden strips; then in case of breakage, the liberated acid will not come in contact with the nails in the boxes containing the carboys.

On account of the liability of glass to crack, sudden changes of temperature should be avoided as far as possible. Neither chemicals nor chemical containers should be placed near steam pipes, nor where the direct rays of the sun will strike them.

Carboys are fragile, and if broken, fire or explosion may result; also there is always danger that acid will spatter on the hands, face and body of the person handling them. Care should be exercised in handling carboys, that they are not dropped, unduly shaken, nor struck by other objects. They should never be moved unless securely stoppered and wired.

Mechanical appliances for handling carboys are nearly all economical and much safer than the simple picking up of a carboy by one or two men. The choice and the successful use of conveyors, roller-skids, derricks with ice tong grips, and various forms of trucks depend upon plant arrangement and the intelligence of the workers. It is impracticable as well as unsafe to use an ordinary warehouse truck because there is no means of securely holding the carboy in place. A better type of truck has a fork attachment, one prong of which passes on each side of the carboy box and beneath the side cleats. It is equipped with large wheels so the carboy can be raised several inches from the floor. The truck can be run in between carboys that are placed close together, it is manipulated by one man, and the carboy need not be touched with the hands at any time during the operation.

Eight methods have been utilized for *removing acid from carboys:*

(*a*) Mechanical pump
(*b*) Pipette
(*c*) Siphon
(*d*) Ejector
(*e*) Inclinator
(*f*) Pouring by hand
(*g*) Manually-operated air pump
(*h*) Introducing compressed air into the carboy

Mechanical pumps are usually of revolving gear type rather than the reciprocating plunger. Such pumps need frequent priming, and this operation presents the greatest hazard. A small supply of priming acid must be kept on hand in another container which should be safely located, covered, and plainly marked. Furthermore, the operator must be careful not to spill acid when priming the pump. Acid pumps that require priming are not recommended.

Pipettes are frequently used—particularly by laboratory chemists—to remove small quantities of acid from carboys. In many plants, drawing acid up into the pipette by mouth suction is prohibited; a suction bottle or hand bulb should be used for this purpose. Care must be exercised to avoid breaking the pipette, and to maintain a good vacuum within the pipette until the chemist empties it.

Siphons are operated by removing the air from the exit pipe or hose; then the ordinary pressure of the atmosphere bearing on the surface of the acid forces the liquid through the exit pipe as long as both ends of the exit pipe are lower than the level of acid in the carboy. No one should ever be permitted to apply his lips to the exit pipe to remove air from the line; a suction bottle or rubber hand bulb should be used.

Ejectors are operated by blowing compressed air through the exit pipe; this creates a suction which draws acid out of the carboy in a steady stream. The air valve should be of the self-closing type, and it should be located as far as practicable from the carboy and the exit pipe. Also, the air hose should be secured to the building structure or to other fixtures, so that in case the hose breaks or becomes disconnected, the escaping air will not strike the surface of the acid and splash it on near-by workers. Ejectors are not considered as safe as some other types of equipment for emptying carboys.

Inclinators.—The safest types of inclinators are those which hold the carboy boxes on top as well as on all four sides; which operate without the expenditure of undue effort; which automatically return to neutral from the pouring position in case the operator loses control of the device; which permit enough motion so all of the acid may be poured out in a smooth, steady stream; and which can be locked in the neutral position to prevent use by unauthorized persons. A splash shield should be attached to the carboy to protect the worker, who should be instructed to operate the inclinator with a slow, steady motion. When pouring acid from a carboy, the man should be instructed to stand to one side, not in front of the acid stream.

Pouring by hand is unsafe and should be prohibited. A worker may subject himself to severe strain in lifting and balancing a carboy on edge. Furthermore, if the worker were to lose his hold on the carboy, the acid might splash or pour out, possibly causing injury to himself and others.

When manually operated air pumps are used, air is forced into the top of the carboy, and this pressure causes acid to flow out of the exit pipe or hose. Pumps are of various types; some operate like a bellows, others like a bicycle pump. If the acid does not start to flow after a few strokes of the pump, the reason should be ascertained and corrected

before further attempt is made to remove the acid. The exit pipe should be examined at regular and frequent intervals to make sure it is not clogged. If this pipe were to become clogged, excessive pressure might be built up in the carboy, resulting in rupture. Air pumps should never be power-operated, as there is too much danger of building up excessive pressure within the carboy. The use of hand-operated air pumps for emptying carboys is not recommended.

Compressed air. Air from compressor lines should never be introduced into carboys. Carboys are not constructed to withstand air pressure, and rupture of such containers might have serious results.

Devices used to remove acid frequently leave a small amount of acid in the carboy. As soon as they are emptied, carboys should be washed out by turning them upside down over an upward stream of water.[15]

Small jugs.—Small containers are also considered by the National Safety Council.

Some operators require only small amounts of acid, sometimes less than a carboy. In such cases, and when carrying samples of liquid chemicals from one department to another, the principal danger lies in accidentally breaking or upsetting the vessel containing the acid. To overcome this hazard a container has been designed that consists of a small jug loosely fitted into a fiber or sheet metal cylinder and packed therein with a tar composition or some other pliable material. The container has a snugly fitting cover and a strong carrying handle.[16]

The most serious accidents in the handling of acids often occur in plants where only small quantities of acid are used. For instance, a plant may have need for only a single carboy of acid during an entire year. In this plant, the recognized or principal accident hazards may be so far removed from the handling of acids and other dangerous chemicals that prevention of accidents from this source may not even be considered. In such a plant little attention may be paid to a carboy of acid, and it is often put away in some dark corner where it will be out of the way until needed. Then some of the acid is required; a workman is sent to fill a pail, and in the attempt to pour acid out of an unwieldy carboy a slip occurs. Or there is some other unexpected spilling and splashing of the acid, with the unusual result: a badly burned workman,

[15] *Ibid.*, p. 8. [16] *Ibid.*

perhaps blinded for life, and $3,000 to $30,000 or more to be paid as compensation for loss of sight.

Accidents of this kind are to be expected unless corrosive chemicals are handled in the small plant with the same care and safety equipment as that used in plants working constantly with large quantities of acids and caustics.

PROTECTION AGAINST REFLECTED LIGHT AND GLARE

Hazards from reflected light or glare and methods of eliminating and guarding against these hazards are discussed in the chapter on lighting. However, a brief comment on protection against glare by the use of goggles may be appropriate here.

The hazard of glare and means of overcoming it antedate American industry. Eskimos have always been confronted with the problem of snow blindness, which is nothing more than the hazard of reflected light, and they early developed an ingenious form of protection—half goggle and half mask. Thousands of American outdoors workmen are exposed to this hazard during the winter months, and even a greater number of men in similar occupations are exposed to the hazard of glare from the sun's rays during the summer months. It is recommended that tinted glasses be worn by persons exposed to glare if they are suffering from certain eye diseases, namely, subacute, acute, and chronic conjunctivitis, chronic blepharitis, blepharoplasm, vernal conjunctivitis, trachoma, iritis, iridocyclitis, incipient cataract, postoperative cataract, retinitis, optic neuritis, photophobia, albinism, and other diseases.

No standards have been established for shades of glass to be used in goggles for protection against glare. In general it is well to select a tint which will absorb all colors of light uniformly so as not to interfere with color perception. Amber, grey, or "smoked" glasses have been found best in this respect. Since goggles of this type are to be had with large lenses, the use of side shields may be left to the discretion of the wearer.

The use of polarized glass is a significant recent improvement

in the development of anti-glare goggles. Goggles made with polarized glass eliminate direct glare and the glare of reflected light, and at the same time they provide for the transmission of a high percentage of light.

PROTECTION AGAINST INJURIOUS LIGHT OR HEAT RAYS

The American Standard Safety Code for the Protection of Heads, Eyes and Respiratory Organs lists two general groups of operation in which there is need of protection from those light and heat rays which have a harmful effect on the delicate tissues of the eye—the ultraviolet and infrared rays.[17] The first group includes those processes in which a moderate reduction in the intensity of the visible radiant energy is required, such as: oxyacetylene and oxyhydrogen welding and cutting; tending electric-arc furnaces; open hearth, Bessemer, and crucible steel making; furnace work; electric resistance welding and brazing; and testing of lamps, involving exposure to excessive brightness. The second group covers processes in which a great reduction of the visible radiant energy is required, such as electric-arc welding and cutting, irradiation with ultraviolet light, and atomic hydrogen arc welding.

Protective measures to be used to prevent the harmful effects of radiant energy may involve use of face shields or head masks with inserts of colored glass. In general, black, amber, and green or greenish-yellow glass is used for protection against ultraviolet rays, while deep black, yellowish-green, or sage-green is best for protection against infrared rays. The darkest black, green, and yellowish-green glass protects against both kinds of rays and also cuts down excessive radiance of visible light.[18]

Standard specifications for the different colors of glass and their densities for filtering out the injurious rays to within safe limits while modifying the visible portion of the spectrum so as to give

[17] The harmful effects of ultraviolet and infrared rays upon the eyes are described in Chapter III, above.

[18] Metropolitan Life Insurance Company, Industrial Health Section, *Health Protection in Welding*, p. 11.

as clear vision as possible have been developed by the National Bureau of Standards. This information is published in Coblentz and Stair, *Spectral-Transmissive Properties and the Use of Colored Eye-Protective Glasses,* United States Department of Commerce, National Bureau of Standards, Bulletin C-421. A standard table of colors for filter glasses indicated by numbers ranging from 1.5 to 14 is presented (see Table 11), by means of which purchasers of safety equipment can determine the properties of the lenses.

Shade No. 3, for example, has a standard density of 0.857 for visible radiation, transmits 13.9 percent of the total visible radiation, a maximum of 9.0 percent of the infrared rays, and a maximum of from 0.2 percent of the ultraviolet rays of the wavelength of 313 millimicrons to 1.0 percent of the ultraviolet rays of 405 millimicrons. The shade numbers in Table 11 refer to lenses intended to be used as follows:

Shades of filter lenses 3 and 4 are intended for protection from the glare of sunlight reflected from snow, water, roadbeds, roofs, sand, etc.; also stray light from near-by cutting and welding operations, and for protection in metal pouring and furnace work.

Shade 5 is intended for wear in light gas cutting and welding and for light electric spot welding.

Shade 6 of filter lenses, is intended for wear in gas cutting, medium gas welding, and for arc welding up to 30 amperes.

Shade 8 of filter glasses is for heavy gas welding and for arc welding and cutting when using over 30 but not exceeding 75 amperes.

Shade 10 is for arc welding and cutting when using over 75 but not exceeding 200 amperes.

Shade 12 is for arc welding and cutting when using over 200 but not exceeding 400 amperes.

Shade 14 is for arc welding and cutting when using over 400 amperes.

In many operations in which radiant energy presents a hazard care must be taken to protect the special colored lenses from breakage or splashes of hot metal by cover glasses. The lenses of these cover glasses must not interfere with vision or strain the eyes, and they must be changed frequently, if they become damaged by molten metal, in order to prevent eyestrain.

Table 11[a]

DENSITIES AND TRANSMISSIONS (IN PER CENT); ALSO TOLERANCES IN DENSITIES AND TRANSMISSIONS OF VARIOUS SHADES OF GLASSES FOR PROTECTION AGAINST INJURIOUS RAYS

(Shades 1.5 to 8, inclusive, are for use in goggles; shades 10 to 14, inclusive, for welders' helmets and face shields.)

	Density for visible radiation[b]			*Transmission (percent)*							
				TOTAL VISIBLE				MAXIMUM ULTRAVIOLET FOR WAVE LENGTH, IN MILLIMICRONS			
Shade No.	*Minimum*	*Standard*	*Maximum*	*Maximum*	*Standard*	*Minimum*	*Maximum total Infrared*	*313 mu*	*334 mu*	*365 mu*	*405 mu*
3.0	.64	.857	1.06	22.9	13.9	8.70	9.0	.2	.2	.5	1.0
4.0	1.07	1.286	1.49	8.51	5.18	3.24	5.0	.2	.2	.5	1.0
5.0	1.50	1.714	1.92	3.16	1.93	1.20	2.5	.2	.2	.2	.5
6.0	1.93	2.143	2.35	1.18	.72	.45	1.5	.1	.1	.1	.5
7.0	2.36	2.572	2.78	.44	.27	.17	1.3	.1	.1	.1	.5
8	2.79	3.000	3.21	.162	.100	.062	1.0	.1	.1	.1	.5
9	3.22	3.429	3.63	.060	.037	.023	.8	.1	.1	.1	.5
10	3.64	3.857	4.06	.0229	.0139	.0087	.6	.1	.1	.1	.5
11	4.07	4.286	4.49	.0085	.0052	.0033	.5	.05	.05	.05	.1
12	4.50	4.715	4.92	.0032	.0019	.0012	.5	.05	.05	.05	.1
13	4.93	5.143	5.35	.00118	.00072	.00045	.4	.05	.05	.05	.1
14	5.36	5.571	5.78	.00044	.00027	.00017	.3	.05	.05	.05	.1

[a] *American Standard Safety Code for the Protection of Heads, Eyes, and Respiratory Organs.*

[b] Standard density is defined as the logarithm (base 10) of the reciprocal of the transmission.

Shade number is determined by the density according to the relation:

Shade number $= 7/3$ density $+ 1$ with tolerances as given in the table.

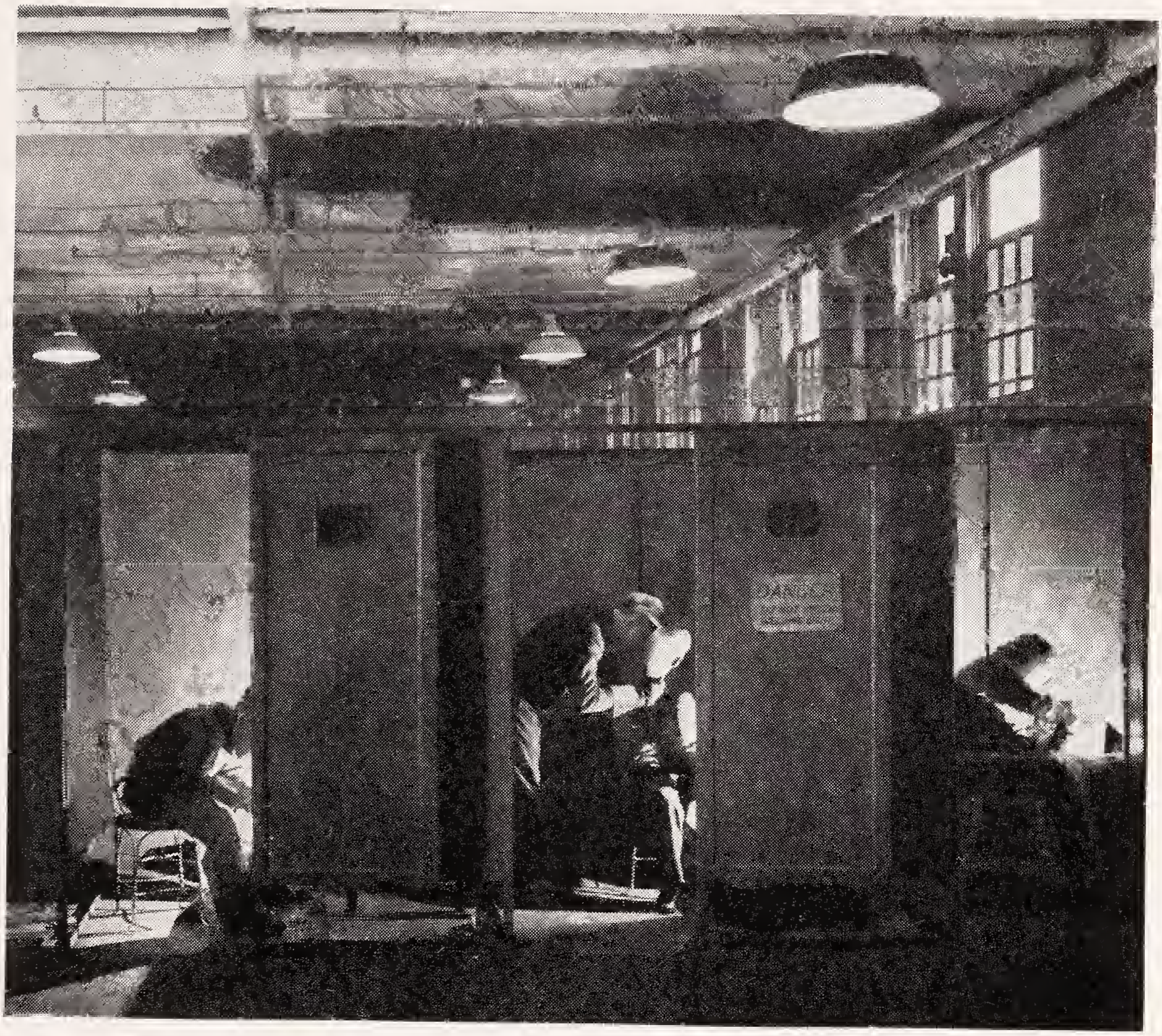

FIGURE 21

ARC-WELDING BOOTHS

Such booths not only supplement the protection of the welders themselves but also afford protection to nearby workmen who are not wearing masks or goggles fitted with special colored lenses.

It should be remembered that workers who are indirectly or temporarily exposed to harmful radiant energy must be protected as well as those directly and constantly exposed. For the protection of men working near an arc welder, for example, opaque screens should surround the arc and the welders, or, better still, a booth should be built around the operator, thereby shutting off the arc rays from the unprotected men working nearby. Care must be taken regarding the painting of the interior of an arc welding booth. If a paint that reflects the rays of an arc is used,

the operator may be subjected to eye flashes from the side and back of the face shield. A paint that will absorb the dangerous rays should be used on the interior of the booth and on all machinery located within it. A simple, non-glossy paint for this purpose is composed of zinc oxide, oil, and turpentine, mainly, which may be given a desired dark tint with lamp black.

In many installations for which a large number of small articles are welded, particularly with regard to the automatic welder, instead of building a booth around the operator to protect outside workers and instead of providing the operator with a mask or face shield, an inclosed cabinet is built around the operation itself, and a colored glass protective window is provided in the cabinet, through which the operator can watch the progress of the welding.

The following is a partial list of operations during which workmen are exposed to radiation which might have a harmful effect

Group	*Process*
Open-hearth steel	Charging machine
	Steel pourers
	Platform men
	Melters
Crucible steel	Melting floor
	Hand pouring
	All steel pouring
Bessemer steel	Pulpit operators
	Blowing steel
	Pouring into molds
Blast furnace steel	Tapping
	Tuyeres
Wrought iron furnaces	Puddling furnace
	Gas heating
	Electric heating
	Large electric heating
Welding	Oxyacetylene cutting
	Oxyacetylene welding
	Iron-arc welding
	Carbon-arc welding

on vision unless protection by means of goggles with colored lenses is afforded.

In the selection of proper equipment for protection against the harmful effects of radiant energy a competent authority, preferably an industrial ophthalmologist, should be consulted. When the services of such a specialist are not available, the National Bureau of Standards of the United States Department of Commerce, Washington, D. C., should be consulted. Reliable manufacturers of protective optical equipment also can be of considerable help in determining the type of lens best suited for use in specific industrial processes involving intense light or heat.

PROTECTION AGAINST MISCELLANEOUS HAZARDS

Many eye hazards in industry do not fall within any of the foregoing classifications. One of the most serious of these is the danger of flying fragments of metal from the burred or mushroomed edges of hand tools. Accidents from this source are usually listed under such all-inclusive and vague designations as "flying objects" or "particles in eye."

Any tool subjected to repeated blows from a hammer or other tools may develop a burred or mushroomed head. Chisels, hammers, swages, flatters, fullers, and all breaking-down tools are most likely to develop mushroomed heads if they are not carefully watched and dressed or ground down at the first sign of a spread. Tools which have been used until the heads have spread and split are among the most serious eye hazards in industry, because a fragment of steel from the mushroomed head of such a tool may be projected at high speed into the eye of a workman at a blow of the hammer. In the larger plants this hazard is generally recognized and properly guarded against, especially when there is central control of tools. Thousands of imperfect tools are, however, still in use on the streets of cities and in many small industrial plants.

Mushrooming may occur on the finest hand-forged tools as well as on those with cast heads such as are commonly provided on cheap hammers. Since less care to secure uniform results is

taken in the manufacture of cheap tools, they are naturally more hazardous than are tools of better quality. The hazard from mushroomed heads is, however, not due to inferior quality alone. The high carbon content of the steel from which many expensive tools are made makes such tools more brittle and therefore more likely to chip than are other tools.

Protection against this hazard may be secured by wearing substantial goggles in all operations where one tool is hammered against another, and this may be supplemented by constant supervision of such work to prevent the use of mushroomed tools. This can best be assured by some regular system for control of hand tools.[19] Frequent periodic inspection of tools should be required in every industrial plant, and a carefully controlled routine should be set up for reconditioning defective tools before they are returned to the worker.

The danger of a flying fragment from a hand tool is as serious when the edges of the tool have just begun to spread as when the tool has become fully mushroomed and the edge cracked. An additional danger in waiting for the heads of mushroomed tools to crack before reconditioning them is the difficulty—if not the impossibility—of getting a true weld when such a tool is put into the forge. The dirt which finds its way into the cracks of mushroomed tools frequently causes such imperfections in the reconditioning of the tool that the first blow of a hammer on the head of the tool will send one or more fragments of steel through the air.

Eyes have been injured or permanently disabled by flying fragments from practically new tools. A glancing blow, some slight imperfection in the tool itself, or any one of a number of factors may at any time cause a chip of metal to be struck from the head of a tool. That is why the greatest protection lies in the wearing of suitable goggles at all times.

In some plants the condition of all hand tools—new and used—is closely checked by one central department responsible for all hand tools in the plant. Every hammer, sledge, chisel, file, and so

[19] See Chapter X, Eliminating Eye Hazards by Administrative Supervision.

forth must be returned to the service shop at the close of the work day, and each tool is carefully examined for defects of any kind before it is released the next morning. In this way a defective or mushroomed tool should be spotted immediately and repaired or replaced before the tool becomes a real hazard.

The hazards grouped in the classifications of the *American Standard Safety Code for the Protection of Heads, Eyes, and Respiratory Organs* are, of course, the most common eye hazards. There are, however, numerous other eye hazards, which occur less frequently, but result in serious injuries when they do occur. Some of these hazards cannot be foreseen. Many can easily be averted by a small investment in dollars or time. Typical of the latter class are the hazards of explosion of water-gauge tubes, flying nails, flying belt clips and the danger of infection of the eye by cutting oils used extensively in the metal-working industries.

When gauge glasses explode there is danger of injury to the eye not only from broken glass but from steam and hot water as well. When the water column is above the eye level of boiler-room workers, gauge glasses should be provided with guards which prevent flying particles of broken glass from striking boiler-room workers and still permit an unobstructed view of the water level. Since the breaking of a gauge glass is a common, expected, and sometimes unavoidable occurrence and since many severe injuries have been received from flying particles of gauge glass, employers should make every effort to secure proper guards.

Many safety engineers feel that the safest gauge-glass valve is the quick-opening, chain-operated type which permits the operator to stand some distance from the glass and control the line of steam and water to the gauge by merely pulling on one of two chains to open or to close the valves, as the case may require. With the screw type of gauge-glass valve it is necessary for the operator, in opening and closing the valves, to expose himself to the danger that the glass may break, and the exposure is of some duration, since it takes considerable time to open and to close the two valves.

The discharge outlets of safety valves should be so arranged

that there will be no likelihood that any person will be scalded or have dust blown into his eyes when the safety valves are opened.

Boiler tops should be kept clear of dust, for there are on record many cases of severe eye injuries resulting from blowing dust from boiler tops into the eyes of workmen.

FIGURE 22

BACKING-OUT PUNCH SHOWING MUSHROOMED HEAD

At any moment a chip from such a punch might damage someone's eye; it should be discarded or dressed.

The danger from flying belt clips is illustrated by an accident reported by a large insurance company. In this case the belt, which was joined by means of metal clips, gave way at the joint, and the clips were expelled with such force that several of them passed through the glass in a window 25 feet away. Such accidents can be averted by regular inspection and careful maintenance of belts and by the use of nonmetallic belt-joining devices. A common cause for the parting of belts at the joints is overloading. The safe working load of a belt may be ascertained from the manufacturer of the belt, and this load should never be exceeded. In too many plants the tension of belts is estimated largely by

guesswork. If the belt is installed or tightened during damp or rainy weather, excessive strain on the belt is almost certain to result when the belt becomes dry, because when wet leather is much more easily stretched than when it is dry. Belts should be examined and belt-tension-scale readings taken periodically.

The hazard of flying nails is more common, particularly in carpentry work and in packing, shipping, and other departments of industrial plants where much nailing is done by hand.

When a workman is engaged throughout the day in hammering nails, the wearing of substantial goggles with side protection should be mandatory. When a number of workmen are engaged in close proximity, the hazard is intensified because of the danger that flying nails will hit men other than the hammerer. Holding the nail improperly and taking the fingers away from the nail too soon are the principal causes of flying nails. Educating workmen to drive nails properly is, of course, one of the most effective means of eliminating accidents from this source. The nail should be held between the finger and the thumb until the point of the nail is well into the wood; the nail should be hit squarely on the head; hammers with scored or corrugated heads will minimize the danger of flying nails.

An enumeration of the miscellaneous eye hazards of all industries would present an almost endless task. The two-year record of eye accidents of a shoe company employing 8,000 workmen is herewith presented as indicating what is probably typical of many industries generally considered as "nonhazardous" as the shoe industry.

Kind of Accident	*Number*	*Kind of Accident*	*Number*
Emery in eye	164	Glass in eye	2
Tack in eye	61	Ink in eye	1
Dirt in eye	54	Scissors stuck in eye	2
Steel in eye	43	Oil in eyes	3
Bruised eye	25	Silicate soda in eye	5
Cut over eye	7	Scale in eye	3
Needle in eye	20	Paste in eye	1
Eyelet in eye	1	Creosote in eye	1
Wax in eye	4	Solder in eye	3
Burned eye	3		

The 403 eye accidents reported by this company constituted 17 percent of all the accidents which occurred in its plants during this period. The experience of this company again emphasizes the fact that so far as eye injuries are concerned there is no such thing as a nonhazardous industry or occupation. This experience, which can proportionately be matched in scores of other industries generally regarded as even less hazardous than shoemaking, is one more bit of evidence leading to the conviction that the best protection against the danger of eye injuries in any work place is a rule requiring all factory workers to wear suitable goggles at all times in the plant.

PROTECTION BY GOGGLES AND GUARDS

Proper Care.—Goggles and guards cannot effectively prevent eye accidents if they do not receive proper maintenance and care. The chief complaint against glass guards has been that employees won't use them because they get dirty. The solution is simple: clean your guards. The usual complaints against goggles include discomfort, lack of visibility, fogging, skin infections, and headaches. All these objections can be overcome by proper servicing and maintenance of goggles and by properly selecting and adjusting them in the first instance. Goggles should be fitted to the face of each individual worker, and arrangements should be made to provide repairs, adjustments, and replacements promptly when needed. Practical procedures should be established for cleaning and sterilizing goggles; all goggles should be periodically inspected to see that they are in good condition and providing the protection that is needed.

Supply.[20]—The method of supplying goggles differs in various plants. In some instances the supply for all shops is kept in the main supply department. In other cases the various shops maintain their own supplies. For the sake of uniformity it is better to have the main supply kept in a central department. However, it is very important that each shop keep on hand, always ready for use, an adequate supply of the goggles for its needs. A suffi-

[20] National Safety Council, *Goggles,* p. 9.

cient supply of repair parts should also be kept in each shop unless there is a central goggle repair department or unless the broken goggles are periodically returned to the manufacturer for repairs.

In a shop where goggles are not used regularly it is a problem to take care of the goggles when not in use. Workmen are inclined to put their goggles behind machines, in drawers, in lockers, in tool kits, on nails, and so forth when they are not in use, with the result that when the goggles are needed they are often difficult to locate. If they are found, they are usually covered with dust and grime and must be cleaned before using.

One company has solved this problem by installing a small cabinet in each department, using old sheet-metal first-aid kits of the wall-hanging type. A series of hooks were put on the inside of each cabinet. Under each hook was placed the name of the employee to whom the goggles are assigned. When the goggles are not in use, the employee returns them to the cabinet. Once each month the goggles are inspected, sterilized, and if necessary repaired. This plan has worked satisfactorily over a period of several years.

Fitting.[21]—The supervisor should see that each man is provided with a pair of goggles suited to his work and a carrying case for his individual use. Care must be exercised to see that the goggles fit each man properly. Considerable time will often be necessary to secure the highest degree of comfort and proper adjustment to facial contour, but many shops have found this time well spent in order to obtain the best results. After the goggles are fitted many shops carefully instruct the worker how to wear them in order to secure the best protection with the maximum comfort.

Often goggles with a headband instead of temples will be worn in such a manner that the headband passes around the widest part of the head. This is not correct adjustment. The headband should be worn so that it passes around the head above the ears and then down near the base of the skull just tight enough to hold the goggles comfortably in their proper position. The headband will be tight enough if the wearer can place two fingers be-

[21] *Ibid.*, p. 7.

FIGURE 23

A GOGGLE-SERVICE MAN

This man has equipment for cleaning, repairing, and refitting goggles for employees right on the job.

neath the band without any appreciable increase in pressure of the goggles against the face.

Men often complain that the goggles hurt their eyes or irritate their skin. All complaints should be investigated carefully. Perhaps imperfect lenses have escaped inspection, or the frames may not be correctly adjusted. Perhaps they need cleaning, or they may not be the correct type. No complaints should be disregarded. Some companies invite criticism from their men in order to get the opinion of the workers on various types of goggles.

Inspection of the goggle lenses sometimes discloses that the glass is so imperfect as to cause eyestrain and headache, because the glass distorts the vision. In such cases the trouble is usually eliminated when the goggles are provided with proper lenses, except, of course, when the man has defective vision. In the latter case there should be provided goggles with corrective lenses or coverall goggles to be worn over spectacles and suitable for the eye hazards to which the worker is exposed.

Many firms have found that the majority of complaints have been overcome by covering all parts of the goggles touching the skin with suitable padding or insuring a smooth finish such as will not discolor the skin when subjected to perspiration.

Cleaning and sterilizing.[22]—After having been worn by one worker goggles should be cleaned and sterilized before issuing them to another employee. Goggles used by one person continuously should also be cleaned and sterilized at regular intervals, preferably each week.

Before sterilizing goggles they should be thoroughly scrubbed and cleaned with soap and hot water to remove grease and dirt and other substances that may be harmful. Goggles should be disassembled and brushed or sponged in a warm water and soap solution and should then be rinsed in warm water and dried.

Use of solvents such as carbon tetrachloride, gasoline, naphtha, or Stoddard Solvent is not recommended for cleaning goggles because of the danger of causing dermatitis if all the solvent has not been removed. Use of solvents may also be injurious to the em-

[22] *Ibid.*, p. 8.

ployee assigned to the cleaning operations. After goggles have been thoroughly cleaned they should be sterilized by a person who fully understands the proper procedure. Recommended methods are as follows:[23]

a) Immerse in boiling water for five minutes.

b) Immerse in live steam for not less than five minutes.

c) Immerse for ten minutes in a solution of formalin made by taking one part of 40 percent formaldehyde solution in 9 parts of water. If it is known that certain parts of the goggles will deteriorate if subjected to the above treatment, the following may be used instead:

d) Sterilize by a moist atmosphere of antiseptic gas, preferably formaldehyde, for a period of ten minutes at room temperature.

Some companies sterilize their goggles by scrubbing with boiling water and a good liquid soap or by the application of ultraviolet light. Another method is to dip the goggles in a 70 percent solution of ethyl alcohol and then dry in air. This method is not satisfactory for goggles with parts made of textile materials. Goggles can also be sterilized by dipping them into a solution made by dissolving one part of sodium hypochlorite in ten parts of warm water. They should then be rinsed in cold water and allowed to dry.

When formaldehyde (formalin), formaldehyde vapor (formalin vapor), sodium hypochlorite solution or ethyl alcohol is used as a sterilizing agent, it is suggested that the operations be carried out in a closed ventilated metal container. This will protect the operator from contact with the irritating fumes. Operators sterilizing with any of these solutions should be provided with rubber gloves, aprons, goggles, and respiratory protective equipment. It is good practice to provide lanolin, cold cream, vaseline, or some similar preparation to be rubbed on the hands and arms to replace the natural skin oils that may have been dissolved by these sterilizing compounds. It is also advisable to follow the instructions given by the manufacturer in connection with sterilizing goggles.

[23] *Ibid.*, p. 8.

Fogging.[24]—Fogging, or condensation of moisture, on the lenses of goggles is influenced to a large extent by the distance of the lenses from the face, type of ventilation of the goggles, and the heat conductivity of the material of which the goggles are made. Castile soap or glycerine soap may be used effectively to prevent fogging. No matter what material is employed, it should be lightly applied to the goggle lenses and wiped off so that it will not interfere with the vision of the worker. However, a single application will not last indefinitely. In some instances one application every three or four hours will be sufficient; in other cases, particularly when the worker is subjected to frequent changes in temperature, applications every hour or oftener may be necessary.

Inspection.[25]—Goggles should be inspected frequently in order to make sure that they are in good condition. While the responsibility of reporting defective goggles generally rests with the worker, his opinion as to what renders a pair of goggles defective may not always accord with the best standards. For example, a pair of welder's goggles may have the cover glasses so pitted by molten metal particles that new cover glasses are imperative for the best interests of the worker's vision, and yet the wearer may neglect or hesitate to ask for the new cover glasses. Periodic inspections will correct such conditions.

Reconditioning goggle lenses by immersing them in acid or by grinding them to remove pitted substances is not recommended. If the foreign substance is dissolved in acid, the pit remains in the lens and causes distortion; if the lenses are ground, they are weakened and may not give full protection. When goggle lenses become pitted, scratched, or otherwise damaged, it is safer to replace them with new ones. Welder's goggles, of course, should be protected with a clear cover glass.

Several industrial plants have solved their goggle-servicing problem by "goggle carts"—portable units stocked with all necessary types of goggles, spare parts, and tools for repairing and adjusting goggles. These carts, staffed by one or two competent employees, make regular tours of the plant, inspecting all goggles

[24] *Ibid.*, p. 7. [25] *Ibid.*

in use, making the necessary replacements, adjustments, and repairs, answering questions, making suggestions, and generally selling to employees the idea of the importance of goggles.

The Pullman Company, which has long been aware of the value of goggle protection, has recently installed an efficient goggle and respirator service department in its Chicago plant. All goggles, masks, hoods, and respirators are turned in nightly to this service station, where they are cleaned, sterilized, inspected, and repaired whenever necessary, and in any event not less often than once a week. A system of checking has also been instituted whereby each employee has his own protective device, used only by him and chosen to protect him against the specific hazards to which he is exposed. This servicing routine has been extremely effective in reducing deterioration of protective equipment and in increasing among employees the appreciation of their value.

False economy of substandard goggles or of permitting workmen to share goggles.—That it is false economy to use mechanical guards and safety devices of inferior quality is a matter of common knowledge among professional safety men. Nowhere is this more true than in the case of goggles and other forms of eye protection. Substandard goggles multiply the causes for objection to the wearing of goggles and often provide justification for them, with the result that some workmen develop a prejudice against all goggles, and it is then difficult to persuade them to wear conscientiously even the best quality and well-fitted goggles.

Notwithstanding these facts there are still hundreds of plants in which the selection of goggles is determined by their price rather than by their suitability for the work in hand or the adequacy of the protection they afford. In other plants men and women engaged in occupations requiring eye protection are permitted or instructed to purchase their own goggles. In such cases many of the workers go to ten-cent stores, small notion stores, or street peddlers and buy the cheapest goggles they can get—often goggles never intended for the purpose for which they are to be used. It is unnecessary to describe the resulting headaches, impaired vision, shattered lenses, and other incidental dangers.

In still other plants the goggles provided are of suitable type and quality, but there are not enough of them. The cigar box containing one pair of goggles for the use of an entire department is still occasionally seen. Often not even a box is provided; a single pair of goggles hangs on a nail above the emery wheel for the use of all who have occasion to use the wheel.

When any one of the three following conditions exists—the provision of low-quality goggles, permission or instruction to employees to buy their own goggles outside the plant, or the provision of only one pair of goggles for a number of workers—it exists because the purchasing agent or the plant manager is not interested in safety work or has not been made to appreciate the fact that expenditures for accident prevention are, not expenses, but investments which invariably pay high dividends. In such cases the first and most important job of the safety engineer is to educate "the big boss" so that he will let it be known throughout his organization that protection of the worker and not immediate economy must determine the purchase of safety equipment.[26]

Methods of supplying goggles to employees.—The basis on which goggles are to be supplied to employees must be determined by each individual employer—the wage scale, the temperament of employees, and other local plant conditions being taken into consideration. A single purpose should be the aim of whatever plan is decided upon—that is, to insure the maximum probability that the goggles will be accepted cheerfully and worn conscientiously. The best goggles in the world are useless when carried in the pocket or worn on the forehead or on a cap.

In many plants where thorough-going safety work is being done goggles are provided without cost to every workman as long as he is employed by the company. This is probably the best plan and the one in most general use. The formality of signing a card which is both a receipt and a pledge to use the goggles has a salutary effect on most workmen.

On the theory that people appreciate most what they have to pay for, some plants require workmen in need of goggles to pay

[26] For further details see p. 195, below.

for them in whole or in part. This theory, of course, is true in the case of certain types of workmen, but when put into practice it is contrary to the spirit in which the most successful safety work has been done.

It has been observed by the National Society for the Prevention of Blindness that the employers who have been most successful in the reduction of eye injuries within their plants have proceeded on the principle that: (1) the employee is entitled to a safe working place and (2) it is good business, even looked at from a selfish point of view, to provide every employee with a safe working place. Nowhere is this more true than in the matter of eye protection.

Chapter VII

ELIMINATING EYE HAZARDS THROUGH PROCESS REVISION

At the outset of the safety movement the emphasis naturally was on mechanical guarding. The fact that accidents could be prevented by simply covering dangerous parts of machines was such a surprising discovery that for a number of years little attention was given to other forms of accident prevention. Unfortunately, even today in many plants accident prevention does not go much beyond this covering-up process.

Then safety engineers began to realize that guarding was not a cure-all; that many workmen were habitually careless, thoughtless, reckless, or ignorant; that personal characteristics were causing accidents which it was impossible to prevent by any form of mechanical guarding. Industries set out to counteract this personal element of industrial hazards by curbing the carefree, careless, reckless spirit of their workmen and by eradicating the ignorance so often the cause of accidents. Safety campaigns were started. Slogans such as "Safety First," "A.B.C.—Always Be Careful," "Safety All Ways," "Don't Get Hurt," and a thousand others were brought into play with good effects in many plants.

This was the beginning of the education movement in the field of accident prevention. In every plant where serious attention was given to accident prevention these two forms of safety work —mechanical guarding and the education of workmen and foremen—constituted the entire accident-prevention program.

Later a third and more fundamental form of accident prevention developed, namely, process-revision, sometimes referred to as "engineering revision." Consequently, in the well-organized plant, the accident-prevention program today first of all considers the possibility of eliminating hazards instead of merely covering them or cautioning workers to steer clear of them. This may involve revision of certain methods of work, a change in the kind of machinery or equipment used, the redesigning of existing equipment, or the building of wholly new types of machinery. It may involve radical changes in plant lay-out, in methods of illumination or ventilation, in materials used. It may call simply for a change in the procedure with regard to details such as distribution and maintenance of tools, piling of stock, or any of the many aspects of good housekeeping or plant management which influence accident rates.

In process revision the aim is to eliminate the underlying causes of accidents and occupational diseases. Process revision is often undertaken for reasons other than safety or elimination of hazards which have nothing to do with the eyes. We are concerned here only with process revision which favorably affects the safety of the eyes in industry, whether this effect is the primary objective of the revision or only the by-product, perhaps even an expected by-product.

The persons concerned with accident prevention and health promotion in a particular industrial property—whether as safety engineer, doctor, nurse, insurance underwriter, owner, or in any executive capacity—can do nothing better than to keep closely informed of any contemplated plant construction or alteration, any impending purchase of new equipment, any introduction of a new process or revision of an old process. If proper attention is given to the accident-prevention and the health-protection possibilities of contemplated improvements when they are first considered (even though they may be planned for reasons of economy, increased production, or any other objective) more may be accomplished toward elimination of eye hazards than through years of effort *after* they have been established; little can be ac-

complished after the building has been constructed, the machinery purchased, or the method of work revised.

EXAMPLES OF PROCESS REVISION FAVORABLY AFFECTING EYE HAZARDS

One of the most effective forms of engineering revision insofar as accident-prevention is concerned is the automatic machine. This reduces the number of operators necessary to turn out any given amount of work, thereby reducing the number exposed to accident hazards. It is, moreover, usually easier to guard the operation of an automatic machine than that of a hand-fed or hand-operated machine. A good example is the automatic glass-blowing machine now used for the production of bottles and glasses. These machines greatly reduce the number of men exposed to the extreme heat of the furnace and the molten glass which often resulted in glassblowers' cataract.

Another automatic machine which has largely eliminated a serious eye hazard is the automatic or machine welder. The protective devices used by hand welders—handshields, helmets, and welding goggles—are quite satisfactory in guarding the eyes of welders. However, as these protective devices are manipulated by the operator himself, the human element is involved, and carelessness or accidental striking of the arc may cause the operator to receive an injury to his eyes. In automatic welding machines the arc is completely enclosed, and the operator observes his work through a window of protective glass. The operator cannot at any time be exposed to the injurious rays of the welding arc. Automatic welding has the further advantage of reducing the hazard of "flashed" eyes among cranemen, welders' helpers, layout men, and others who are continuously exposed to this danger when employed in the vicinity of uncovered welding operations.

Accident hazards may be eliminated by merely changing the position or the design of a control lever. For example, the operator of an old-type wire-drawing machine was exposed to the danger of being struck by loose ends of wire. When the wire broke or the last piece of wire was reached, the end would fly up, often

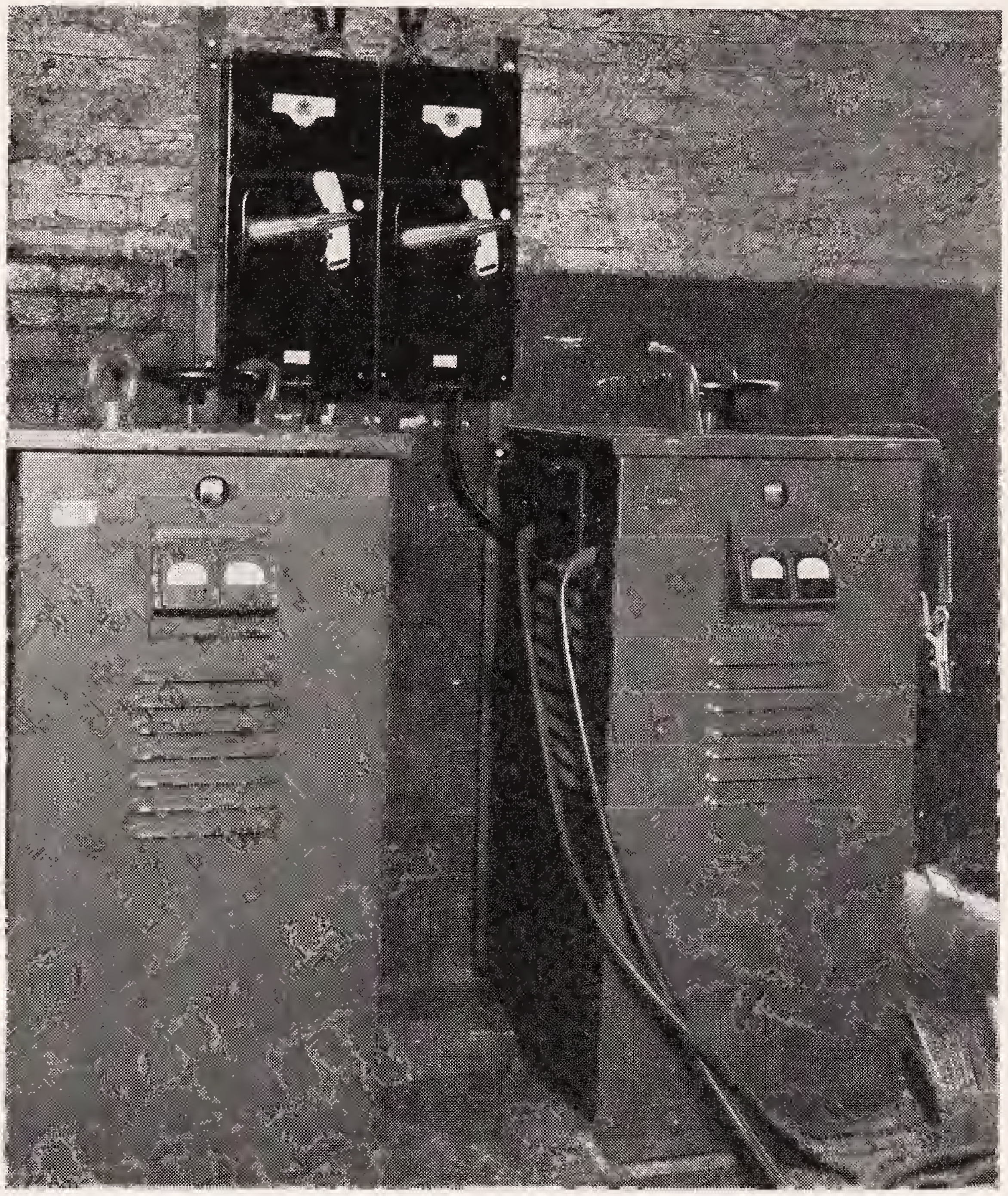

FIGURE 24

AUTOMATIC MACHINE FOR WELDING PROPELLER SHAFTS

Such machines eliminate eye hazards in welding. This photograph illustrates a type of installation consisting of two 500 ampere alternating-current type welders, installed for stationary service. These machines are, of course, totally enclosed and no connection can be made to the primary side without the services of a qualified electrician. The operator touches no current carrying parts in adjusting the machine. Individual line safety switches are provided for each machine. The frames of these machines are solidly grounded.

inflicting severe puncture wounds on the eye. These ends were the more dangerous because the treadle used to shut down the wire-drawing block was in such a position as to bring the operator close to them. This hazard was eliminated by furnishing the oper-

ator with the means for shutting down the block from a distance sufficient so that the end of the wire cannot reach him. Later, the machine was redesigned so that it would shut down automatically when the wire breaks or when the last end runs through the die.

A form of process revision most common in modern industrial plants is the substitution of nontoxic substances for toxic ones. A typical example is found in the rubber industry, in which ammonia is used as a solvent for latex. Ammonia in solution will volatilize easily, and the result is irritating to the eyes, mucous membranes, and respiratory system. In large amounts ammonia gas may be fatal. This hazard was completely eliminated by the substitution of fixed nonvolatile alkalies for ammonia. Such alkalies cannot liberate toxic gases.

Control of poisonous dusts, gases, and vapors presents an industrial problem often effectively solved by process revision. The uncontrolled flowing of the first oil wells presented such a problem when large quantities of volatile oils and gases were released. These toxic substances were a serious hazard to the eyes. Eventually pressure devices were developed to control the output of the wells, preventing the escape of the poisonous oils and gases.

A serious dust hazard exists in the abrasive cleaning of castings in foundries. The dust resulting from the use of sand as an abrasive has caused many costly eye injuries as well as the frequently fatal disease, silicosis. It was found that dust concentration was considerably reduced when metal shot was used as an abrasive instead of sand. Scientific dust counts show that whereas the concentration of dust particles when sand was used was 969,000,000 particles per cubic foot when metal shot was used the concentration of dust was reduced by 85 percent, to 155,000,000 particles per cubic foot.[1]

The oldest and simplest form of dust control is wetting down the particles. Wetting is still used, primarily in rock drilling, with considerable effectiveness. Dust counts indicate that wetting cuts the dust concentration created by rock drilling from 614.5

[1] Bloomfield and Dallavalla, *The Determination and Control of Industrial Dust*, Public Health Bulletin, CCXVII (1935), 74.

million particles per cubic foot to 11.2 million particles, a reduction of 98 percent.[2]

Sometimes process revision is just good common sense applied to an industrial situation. Here are two examples: For years the most serious eye hazard in a midwestern steel plant, as in many other plants, was the use of pneumatic chisels to cut off rough spots from castings. The hazard was due to the fact that in the interest of speed two men would work on each casting, one starting at one end and one at the other, facing each other. Consequently chips of steel cut by each worker's high-powered chisel might fly into his "buddy's" face. Even if both men wore goggles consistently (which they did not always do) this process presented unnecessarily a most serious eye-accident hazard. Eventually, someone thought of having the two chippers start their work on the casting from the middle instead of from the ends and when standing back to back instead of facing each other. Immediately eye injuries became a thing of the past in this department.

More recently a somewhat comparable procedure wiped out a prolific source of eye injuries in another foundry. Here, as is still the practice in other plants, long benches were used, where castings were removed from the molds. Several men worked at one bench, side by side. The men often burned one another when they turned to place empty molds back on the pouring table. Furthermore, flying fins often caused serious eye injuries. After this dangerous practice had gone on for years, the head of the department realized that individual mold-changing tables would wipe out the hazard. Consequently the large benches were discarded and small tables were set up, one behind the other, with one man at each table. Each man was then out of range of the flying fins and had no one at his side when he turned to place the mold back on the pouring table. This not only eliminated accidents but also increased production, because each worker had his own pan before him and did not have to turn or to walk to the end of a long table. Wiping out the fear of being burned or

[2] *Ibid.*, p. 75.

FIGURE 25

A SAFE AND EFFICIENT CASTINGS-CLEANING DEPARTMENT

Fine particles, which ordinarily would fill the air, are exhausted through the grills on which the castings are placed; heavy particles, which ordinarily would shoot out at great speed, are caught by the circular guards.

cut by fins soon showed its beneficial effect in better morale as well as in greater production and fewer injuries.

The Pullman Company, which has set the pace for American industry in the prevention of eye injuries through the success of its mandatory goggle rule, is now conducting another experiment which may wipe out one of the principal sources of industrial eye injuries. This company has recently instituted a central control of hand tools through which the tools of every worker are collected each night, examined, reconditioned, and returned to him the following morning in a condition conducive to safety instead of to accident. Because of this control every tool with a mushroomed head is spotted immediately and corrected. Elimination of this one hazard throughout American industry would save hundreds of men from blindness and other serious losses of vision now resulting from the laceration of eyes by flying fragments from the heads of mushroomed tools; it would save each industry many times the cost of maintaining a central tool control.

The substitution of the welder's torch for the high-powered chisel is another instance of process revision which has greatly reduced some of the most serious eye-accident hazards of industry. The Union Pacific Railroad System, for example, reports a decided reduction of eye accidents following general adoption of the oxyacetylene torch for cutting off bolts, rivets, studs, and keys in the repair of locomotives and cars, the dismantling and repair of bridges, tanks, and steel building structures. Other companies have adopted the same practice with equal success, thereby eliminating the danger of flying rivet heads which constitute a hazard to the eyes, and in fact the life, of all those in the vicinity of steel demolition when this is done with pneumatic chisels.

In steel plants, too, the process of chipping castings with pneumatic chisels has been replaced by the practice of burning off the rough spots with the welder's torch. This practice, of course, increases the danger of exposure to injurious ultraviolet and infrared rays incidental to welding, but this hazard is much more easily and successfully guarded against than is the hazard of flying fragments of steel castings or flying rivet heads.

These are only a few of the many instances in which process revision has effectively reduced or eliminated serious accident and disease hazards to the eyes. The whole subject of accident prevention by process revision is, however, still more or less in its infancy. This is true because many safety engineers believe it is impossible to revise an industrial process so that it will be completely nonhazardous. In the words of one engineer, "Years ago we quit trying to determine where the eye hazards were. We never were able to guess all the possible hazards, so we put goggles on all the men and let the chips fall where they may."

On the other hand, more and more safety engineers are beginning to realize the value of process revision. Experience has shown that it is also effective in the elimination of occupational accident hazards.

It is desirable to develop to the utmost the possibilities of process revision as a means of preventing injuries to the eyes of industrial workers because most American industries have found it impossible to employ with complete success safety methods which are dependent upon the human element or upon the full and consistent coöperation of workmen, foremen, and the higher supervisory officials. When considerations of safety—even personal safety, let alone the other fellow's safety—have to compete with the pressure for speed, quick deliveries, maximum production, or the inordinate ambition of certain workmen, foremen, or superintendents, they lose out—that is, when men who ought to know better deliberately "take a chance." Process revision, on the other hand, may make it impossible for the worker or his supervisor to take a chance. Whereas it is easy enough to put one's goggles aside, even to shove a guard to one side or take it off the machine altogether, to forget a bit of "safety education" or to disregard "safety rules," it is not possible to circumvent so easily safety measures such as some of the instances of process revision reported above.

It is, of course, not possible to eliminate every eye hazard by process revision. Nor does process revision always take the place of guards, goggles, education, supervision, and safety rules. It is

urged here because the great majority of industrial plants have been unwilling to or for some reason unable to follow the example of the few which have eliminated eye accidents, or come close to eliminating them, through a combination of: (1) complete mechanical guarding; (2) thoroughgoing safety education; and (3) a mandatory rule that goggles must be worn by every person in the plant. Process revision should be added to all these other activities in any plant which really intends to save the eyes of its employees and to reduce the accident and occupational disease costs of the company.

How does a safety engineer go about getting a hazardous process revised? First of all, he must discover exactly what the hazard is and its fundamental cause. It may be a step in a century-old manufacturing process; it may be the escape of dust, gas, or vapor; it may be a chemical substance which was not known to be toxic; it may be an ordinarily nonhazardous mechanism made dangerous by a personal factor, such as the piece-worker's willingness to take a chance in order to increase his output and wage. Having discovered the hazard, why it is dangerous, and how it injures the workers, the safety engineer can follow several courses. If a poisonous chemical substance is involved, perhaps nontoxic substitutes can be found. All available information on new materials should be studied: solvents, degreasing agents, paints, dyes, bleaches, abrasives, and so forth. If a dust, gas, or vapor is involved, perhaps ventilation, isolation, or enclosure of the hazardous process or wetting down the dust will be effective.

Knowledge of certain fundamental factors applicable to inspection for poison hazards can be very helpful to the industrial safety engineer or safety inspector. The following outline[3] indicates what these fundamentals are:

1. Determine the raw materials (for our purpose all materials brought into the plant for processing or for use in the process are raw materials). In some cases materials as solvents, binders, dye bases, rub-

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[3] United States, Department of Labor, *Report of Proceedings of a Training Course for State Factory Inspectors,* U. S. Dept. of Labor Bulletin No. 6, p. 28.

ber accelerators, etc., are known by trade names only. In such cases it may be necessary to press the inquiry to the firm manufacturing them.

2. Wide knowledge of the way in which each toxic substance may gain access to the system is essential. As for instance, lead—by inhalation and not, except in most exceptional circumstances, through the skin; chromium—chiefly as an acid mist; analine—chiefly through the skin.

3. With a knowledge of exactly what toxic materials are used, find out the conditions under which each is used and the extent of the exposures entailed. When dusts, fumes, or gases are the sources of hazard it is important to remember that the chief factors are concentration and length of exposure.

4. The exposures that are not clearly nonhazardous should be clearly studied. Dust counts should be taken and analyses made to determine percentages of the toxic substance present in relation to known threshold limits. The presence of such substances as mercury, lead, or arsenic on walls, floors, etc., should be investigated.

5. Possible results if processes are not kept under control (as overheating, tank or line breaks, etc.) should be studied.

6. The generation or release of hazardous fumes that may result from fire should be considered.

7. Hazards arising from the handling and storage of dangerous supplies as acids, caustics, solvents, gases under pressure, celluloid, and nitrocellulose, powerful oxidizing agents, etc., should receive careful attention.

8. Equipment for emergency and reserve purposes should be very carefully determined. Its location, maintenance, and training in its use are obviously of vital importance.

9. The actual record of the plant should be studied as far as it is available and if not already kept, the keeping of the necessary records should be arranged. For complete information all absences and turnover should be investigated, though in practice it is difficult to secure more than such a check-up on the workers in occupations which have an admittedly high hazard.

If machinery is involved, the solution may lie in an automatic feed or release, the separate housing of a dangerous unit, or rearrangement of the machines. If all else fails, perhaps a change in machine design will be effective; rounding the edge of a die may save fingers; modifying the tilting carriage of an acid carboy may save eyes.

There is much the safety engineer can do toward process revision in the interest of accident prevention and health promotion, but this phase of his work more than any other calls for the coöperation of many other executives in the plant. In fact, as was implied at the beginning of this chapter, in the field of process revision the safety engineer is likely to be, and properly so, not the prime mover, but the one who is merely coöperating with other departments more directly concerned, particularly the purchasing department, the plant construction and maintenance department, the chief engineer's office, the chief tool and die maker, the chief chemist, or the company's various consulting engineers.

In the consideration of any disease hazard the safety engineer should have the coöperation of the plant physician or (when there is no plant doctor) of a consulting physician, preferably with industrial practice or experience. In determining the toxic effects of certain substances[4] or the maximum safe concentrations of poisonous dusts and gases the services of a medical man are indispensable. A copy of Dublin and Vane's pamphlet[5] on industrial poisons is an excellent reference work to be used in the study of chemical hazards. Careful maintenance and analysis of accident records will be of great assistance in efforts to eliminate hazards. Careful observation of the men at work may reveal clues not available in the accident reports.

There are great opportunities for the prevention of eye accidents through process revision. Such improvements as are made, however, should be considered supplementary to the protection afforded by guards, goggles, and other standard head protection until the new process, machine, or tool has been in operation for a sufficient period to demonstrate beyond a doubt that the process is safe without the use of guards or goggles.

[4] See Chapter III, above, and Appendix II.

[5] Dublin and Vane, *Occupation Hazards and Diagnostic Signs.*

Chapter VIII

ELIMINATING EYE HAZARDS THROUGH PROPER LIGHTING

No person in a factory, shop, office, store, or other place of employment can do his work efficiently unless he can clearly and comfortably see what he is doing. Despite the tremendous progress that has been made in industrial lighting, this fundamental principle of industrial hygiene and business efficiency still is violated in thousands of factories and offices.

> Blindfold even the most skilled mechanic and he is practically helpless [says the National Safety Council]. Any piece of work he attempts to do will doubtless be spoiled and, furthermore, he may injure himself or some other worker. Workers in poorly lighted factories are, in effect, partially blindfolded. Many manufacturers who supply their employees with the best of tools and equipment fail to consider the importance of the workers' eyes and the handicap of poor lighting.

That the situation is even more serious than might be supposed from this statement was shown by a survey[1] of lighting conditions in representative plants in the major industries of the United States since 1935, made by the Industrial and School Lighting Committee of the Illuminating Engineering Society. This study disclosed that more than half the plants surveyed were using obsolete lighting equipment—and there is no reason to suppose conditions have changed greatly since then—and that these plants would have to increase their illumination on an average more

[1] Dates, "A New Approach to the Industrial Lighting Problems," *Electrical Engineering,* LVI (May, 1937), 545–50.

than 400 percent in order to provide adequate lighting for their workers.

In some industries—chemical, canning, building materials, printing, paint and varnish manufacture—more than 80 percent of the shops were found to have obsolete lighting equipment and in several of these industries, investigators found less than one-tenth as much light as was needed for efficiency and safety. Assuming that the conditions disclosed by this survey were typical and applying the averages found to the total number of plants in the respective industries, as reported in the Federal census of 1930, the Illuminating Engineering Society presents the following table.

TABLE 12

LIGHTING CONDITIONS IN AMERICAN INDUSTRY[2]

Industry	*Number of Plants*	*Age of Equipment in Years*	*Average Foot-Candles in Factory Interior*	*Percentage of Increase Necessary for Good Lighting*	*Percentage of Plants with Obsolete Lighting Equipment*
Baking	15,684	7.5	1.24	195.	32.1
Building materials	14,792	8.1	0.5	1500.	82.
Canning	2,917	11.7	0.6	1150.	83.
Chem. manufacturing	8,871	9.3	1.3	208.	81.7
Food, candy & dairy	46,113	8.9	3.1	271.	65.2
Glass	8,478	5.6	1.2	460.	35.
Laundry	21,926	5.5	4.75	139.	41.3
Leather goods	4,796	6.5	6.88	62.5	33.7
Mach. and tool mfg.	11,807	6.57	5.1	106.5	27.3
Metal working	12,021	9.57	1.3	562.3	63.2
Paint and varnish	923	17.1	1.4	494.	87.3
Printing	22,725	5.4	5.5	109.	87.3
Paper manufacturing	3,783	10.	5.29	193.	25.
Refining	2,906	6.8	0.02	592.5	72.
Rubber goods	498	7.2	0.8	496.	67.3
Shoe manufacturing	1,460	4.3	1.8	263.	63.4
Textiles	24,443	5.3	7.0	115.2	21.3
Woodworking	16,527	4.0	3.6	367.	62.4
Totals and averages	220,670	8.74	2.85	404.7	54.0

[2] *Ibid.*, p. 547.

Is it any wonder that as a result the worker suffers from eyestrain or from one or more of the many disorders which have their root in eyestrain and that industry suffers from decreased production, increased spoilage and errors, increased personal injuries and compensation costs, and lowered plant morale?

The proper lighting of factories and other work places has always been important from the standpoint of conservation of vision and prevention of blindness, as well as from the purely economic point of view. It is yearly becoming increasingly important, for these reasons:

1. The steady growth of industry in general and particularly the development of new types of machinery and new industrial processes increase continually the number of accident hazards to be guarded against. These hazards are further increased by improper or insufficient illumination.

2. Modern methods of mass production with emphasis on speed often subject workers to continuous eyestrain for hours. This eyestrain continued over months and sometimes years, results in permanent impairment of vision and often impairment of general health, with the inevitable consequences of increased accident hazard, lowered volume and quality of production, and more difficult employer-employee relations.

3. Despite the progress represented in the so-called daylight type of new plant construction, the use of artificial lighting in industry is increasing. During recurring periods of intense business activity in certain industries, the twenty-four-hour plant is becoming more common, which means that two out of three shifts of workers in such plants depend entirely on artificial lighting. In many industries fine detail work is becoming so complex that even the best available natural light does not provide adequate illumination. The gauge rooms of airplane factories, for example, require constant illumination of fifty to one hundred foot-candles with a complete absence of shadows. Certain processes in the printing industry require a high degree of illumination with low source brightness and even distribution. Sewing of dark goods and inspection of fine detail in a great variety of industries require strong directional light with no glare. These specialized requirements of illumination can rarely be satisfied by natural lighting. The fact is that millions of men and women work in factories, shops, stores, offices, and other places which are inadequately lighted even during the sunniest hours of the brightest days.

ACCIDENTS CAUSED BY POOR LIGHTING

The effects of poor illumination on production efficiency and on the accident experience of industrial plants are similar to the effects of defective vision described in Chapter IV. The National Safety Council has estimated that poor lighting is the direct cause of 5 percent of all industrial accidents and that the cost of these

FIGURE 26

TYPESETTING DEPARTMENT EXCELLENTLY LIGHTED BY UNITS OF HIGH CANDLEPOWER AND LOW SURFACE BRIGHTNESS

accidents is $75,000,000 annually. It is further estimated by the council that poor lighting is a contributing cause in about 20 per-cent of all industrial accidents, and the cost of these accidents is calculated to be $300,000,000 a year.

In view of these estimates it is shocking to recall the Illuminating Engineering Society's findings that in half the work places of the country men and women are required to work in approxi-

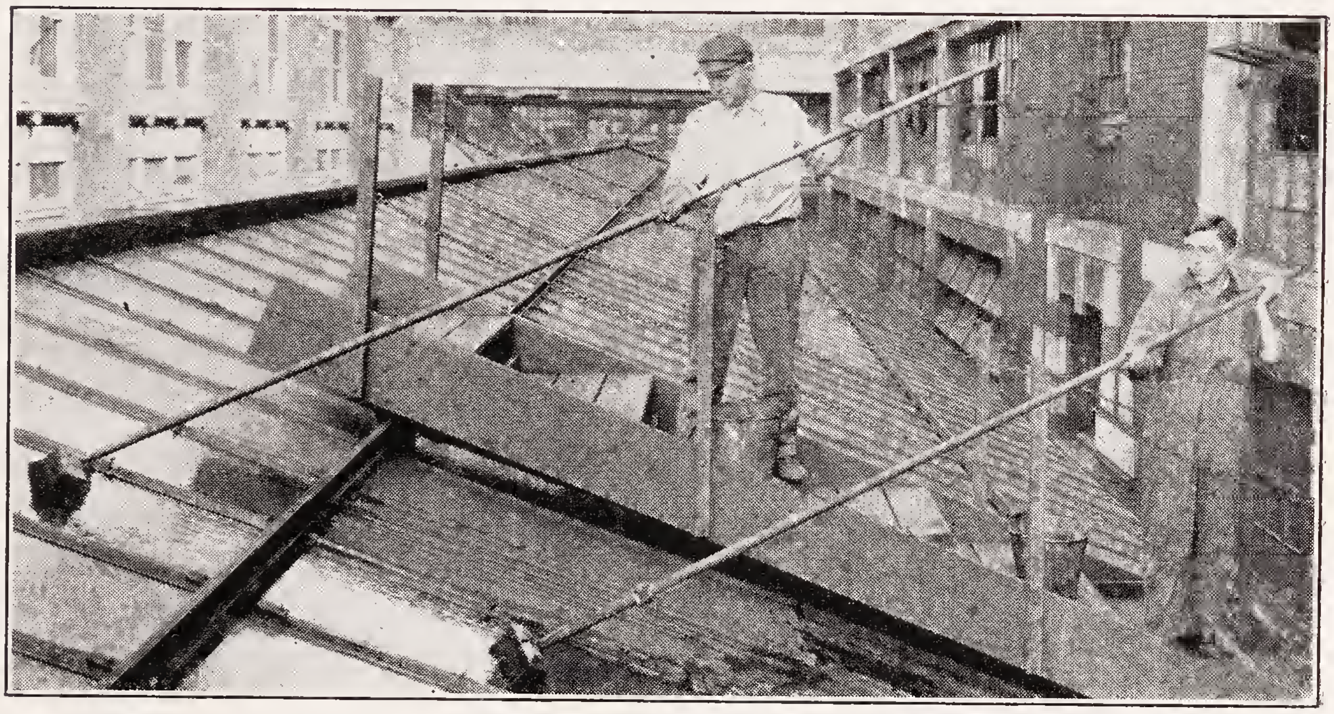

FIGURE 27

THE WASHING OF WINDOWS AND SKYLIGHTS AS A MEANS OF REDUCING ACCIDENTS AND EYESTRAIN AND INCREASING PRODUCTION

Wise modern industrial executives spend tens of thousands of dollars yearly for this purpose.

mately one-fifth the amount of light they ought to have for efficiency, safety, and good health. This fact and the fact that bad lighting has been demonstrated to have harmful effects on the eyes of factory workers and on the quality of their work make toleration of improper lighting in a work place a clear sign of incompetence.

One reason for the persistence of bad lighting throughout all the years of education by the lighting interests and safety organizations is that in many plants lighting has not yet been taken out

of the janitor-service class and placed where it belongs—in the class with labor-saving devices and safety equipment.

Studies by the United States Public Health Service in two New York City post offices show what effect the intensity of illumination has on the incidence of eye defects.[3] Two post offices differing markedly in intensity of illumination were chosen for the study —one, the old City Hall post office, in which the lighting was antiquated, and the other the general post office, in which the illumination was more adequate. The 2,400 employees in the two post offices were comparable in age distribution and in years of service, and the work processes in the two buildings were similar.

The prevalence of defects and diseases of the eye was found to be much greater in the City Hall post office than in the general post office, as is shown in Table 13 below. It will be noted that the percentage of employees having certain defects of vision was much greater in the older post office and also that the percentage of employees having 20/20, or normal, vision was greater in the newer post office.

Table 13

PERCENTAGE OF THE 2,449 EMPLOYEES EXAMINED IN THE NEW YORK CITY HALL AND GENERAL POST OFFICES WITH CERTAIN EYE CONDITIONS

Post Office	*Normal Vision in Both Eyes with No Defects*	*Normal Vision in Both Eyes with Defects*	*Normal Vision in One Eye Only*	*Normal Vision in One or Both Eyes*	*Defective Vision in Both Eyes*	*Refractive Errors*	*Inflammatory Conditions*	*Muscular Unbalance*	*Asthenopia*
City Hall P.O.	10.3	29.5	17.8	57.5	42.5	76.6	20.9	33.4	16.5
General P.O.	19.8	29.9	17.6	67.4	32.6	72.5	11.9	22.4	5.7

The most significant figures in the table are those in the last column. Asthenopia, weakness or rapid fatigue of the eyes, often accompanied by pain and headache—or eyestrain—was three times as great in the poorly lighted City Hall post office as in the well-illuminated general post office.

What is true here is undoubtedly true throughout industry.

[3] Ives, "The Social Significance of Better Sight," *The Sight-Saving Review,* V (1935), 116–25.

In other words, going back for a moment to the findings in the Illuminating Engineering Society study, in 54 percent of 220,000 industrial plants three times as many workmen suffer from the avoidable fatigue, headaches, and other pains that come from persistent eyestrain as suffer from the same causes in the 46 percent of American industries which are well lighted.

THE NEW SCIENCE OF LIGHTING

While it is possible for the layman to measure fairly accurately the amount of illumination which exists under any given condition of work by use of the foot-candle meter or the even more accurate photo-electric-cell light-measuring instruments, it is not so simple a matter to correct the defects of a bad lighting system or to set up an original lighting installation adequate for the particular work to be performed under it and for the particular men and women who are to do this work. Only in comparatively recent years have even illuminating engineers and others professionally concerned with good industrial lighting come to realize that the designing of proper lighting systems calls for a thorough understanding of the problems of vision as well as those of illumination.

The new approach to industrial lighting necessitates careful study of the visual task entailed by each manufacturing process. The act of seeing involves recognition of outline, of size, of form, and of detail; perception of light and shade; quickness to see objects, especially in observing rapidly moving objects; the brightness of the object contrasted with that of the immediate background and the more distant surroundings; color and glare. All these factors of seeing must be considered in order to determine the right quantity and quality of light for a particular occupation and even for a minor part of a specific industrial operation.

LIGHTING CODES

In line with this new approach to industrial lighting it is not sufficient to rely merely on lighting codes in setting up lighting systems for specific operations. Lighting codes indicate, in gen-

eral, the amount of illumination needed for a particular type of work. The codes cannot, however, answer questions about types of lighting unit, position of lights, types of reflector, and other problems which arise in the design and installation of a particular lighting system.

To satisfy the need for more specific information concerning industrial lighting the Industrial and School Lighting Committee of the Illuminating Engineering Society has been making a series of studies concerning the lighting problems of individual industries. Thus far, this series has dealt with the printing industry, the textile industry, shoe manufacturing, the cleaning and pressing industry, and the candy-manufacturing industry.[4] These reports analyze in detail the lighting problems of each process in the industry studied and make recommendations as to the most practical and economical lighting systems to solve these problems.

It is the purpose of this volume, not to present in detail the technical specifications of good illumination, but rather to point out its importance, especially from the standpoint of sight conservation. The technical details are to be found in the Illuminating Engineering Society's *Recommended Practice of Industrial Lighting* and other documents of that society.[5]

[4] These studies will be found in the following issues of the *Transactions* of the Illuminating Engineering Society:

"Progress Report on Lighting in the Printing Industry," XXXI (March, 1936), 277–313.

"Report on Lighting in the Textile Industry—Grey Goods and Denim," XXXII (March, 1937), 247–81.

"Report on Lighting in the Shoe Manufacturing Industry," XXXII (March, 1937), 289–314.

"Lighting for the Cleaning and Pressing Industry," XXXII (June, 1937), 613–27.

"Lighting for the Candy Manufacturing Industry," XXXII (May, 1937), 483–504.

"Studies in Lighting of Intricate Production, Assembly, and Inspection Processes," XXXII (Dec., 1937), 1019–53.

"The Lighting of Power Presses," XXXIV (Feb., 1939), 153–75.

"Lighting of Machining of Small Metal Parts," XXXIV (Jan., 1939), 21–54.

Studies now in preparation include heavy iron and steel machining and finishing, suede and kid leather manufacturing, rubber manufacturing, and men's clothing manufacturing.

[5] A simple and authentic guide to proper light intensities in the various departments of more than 60 major industries, prepared by the Illuminating Engineering Society, appears in Appendix III of this volume.

The National Society for the Prevention of Blindness is concerned with the promotion of adequate and otherwise efficient lighting of industrial work places because the resulting reduction of accidents generally would reduce eye accidents proportionately and also because proper illumination reduces eyestrain.

It is possible for the layman to measure accurately the amount of illumination which exists under any given conditions by the use of the foot-candle meter, a simple and relatively inexpensive instrument designed for practical use where a laboratory photometer and trained operator are not available. The directions which accompany the instrument enable the operator, after some practice, to measure foot-candles accurately enough for most practical purposes. In most cities a foot-candle meter may be borrowed from the local lighting company or from the local society for the prevention of blindness. It is a wise policy in any industrial establishment of reasonable size to obtain one of these instruments and to check up at regular intervals on the efficiency of the lighting system in use in various work rooms. This check-up should be made preferably by an illuminating engineer or, at least, a person thoroughly familiar with lighting codes and the use of light-measuring instruments, since it is the opinion of some lighting experts that a foot-candle meter in the hands of a novice may sometimes yield incorrect results.

EFFECT OF LIGHTING ON PRODUCTION EFFICIENCY

Illustrative of the fact that efficiency and comfort of work are substantially increased as illumination is increased, the Electrical Association of New York reports the following results of an experiment:[6]

As illumination is *increased* working time is *reduced.*

ILLUMINATION (In foot-candles)		WORKING TIME	
From	*To*	*Percentage with Normal Vision*	*Percentage with Defective Vision*
3	12	28	40
6	12	15	20
12	48	10	12

[6] Electrical Association of New York, *Good Industrial Lighting Pays.*

If personal preferences as to intensity of light constitute any measure of the proper amount of lighting required by an individual for safety and efficiency (and there is good reason to believe that they do), the following results of an experiment which represented the preferences of 82 persons, reported by Luckiesh and Moss,[7] are significant:

NUMBER OF FOOT-CANDLES PREFERRED BY READERS

Percentage of Readers	*Most Desirable Number of Foot-Candles*
11	10
18	20
32	50
20	100
17	200
1	500
1	1000

In the experiment upon which this latter table is based a large number of readers were asked to pick the reading light which best suited them.

On the basis of these and of similar tests in the laboratory and in work places Luckiesh and Moss set up the following scale of illumination requirements,[8] a scale that presents a compromise between optimum lighting conditions (which are known to be much greater) and those conditions usually available with present-day lighting installations:

100 foot-candles or more.—For very severe and prolonged tasks, such as fine needlework, fine engraving, fine penwork, fine assembly, sewing on dark goods and discrimination of fine details of low contrast as in inspections.

50 to 100 foot-candles.—For severe and prolonged tasks such as proof-reading, drafting, difficult reading, watch repairing, fine machine work, average sewing and other needlework.

20 to 50 foot-candles.—For moderately critical and prolonged tasks such as clerical work, ordinary reading, common bench work, and average sewing and other needlework on light goods.

[7] Luckiesh and Moss, "The New Science of Lighting," in *Transactions* of the Illuminating Engineering Society, XXIX (1934), 662.

[8] *Ibid.*, p. 661.

10 to 20 foot-candles.—For moderate and prolonged tasks of office and factory and when not prolonged, ordinary reading and sewing on light goods.

5 to 10 foot-candles.—For visually controlled work in which seeing is important, but more or less interrupted or casual and does not involve discrimination of fine details or low contrast.

0 to 5 foot-candles.—The danger zone for severe visual task and for quick and certain seeing. Satisfactory for perceiving larger objects and for casual seeing.

Elimination of glare is assumed in all values given in this table. The foot-candle values apply, of course, to natural as well as to artificial lighting.

LIGHTING PROBLEMS

AVOIDANCE OF GLARE

Glare has been defined as any brightness within the field of vision of such a character as to cause discomfort, annoyance, interference with vision, or eye fatigue. It is one of the principal causes of eyestrain and is therefore always to be avoided, yet it is one of the most common defects of lighting systems. The scientific measurement of glare must be left to the illuminating engineer and to the physicist. It is possible, however, for the layman to recognize most of the conditions which cause glare. The causes and effects of glare are defined in *Recommended Practice of Industrial Lighting.*[9]

Glare is objectionable because (1) when continued, it tends to injure the eye and to disturb the nervous system; (2) it causes discomfort and fatigue and thus reduces the efficiency of the worker; (3) it interferes with clear vision by contracting the pupil of the eye and thus increases the risk of accident and injury to the worker. Every effort should be made to eliminate glare in work places, whether it is caused by daylight or by artificial light.

Glare by reflection.—Glare may be produced by the reflection of light from polished surfaces in the field of vision. The difficulty experienced in protecting eyes from this kind of glare is sometimes very great. One of the most common forms of glare by re-

[9] Illuminating Engineering Society, *Recommended Practice of Industrial Lighting*, p. 16. (Now in process of revision by the Illuminating Engineering Society.)

flection is that caused by bright light on the glossy printed page. The arrangement of series of glass partitions, showcases, mirrors or doors in offices, stores, and showrooms sometimes causes glare by reflecting sunlight or electric light. Glare by reflection can be found also in the typesetting tables of the printing industry, where the edges and the corners of type characters wear down to form concave and convex mirrors which reflect light.[10] Glare frequently occurs on highly polished surfaces which are being inspected for the detection of flaws, scratches, or blemishes—an operation required in many industries.

NATURAL LIGHTING

It would be fortunate for mankind if all work could be done under daylight illumination—the ideal lighting for the eyes. Hence every effort should be made to use daylight for as much of the working time as possible. The experience of numerous industrial plants has demonstrated that good illumination increases production far beyond the cost of installation, and this is as true of natural as of artificial lighting. The economic value of daylight has become so well known that nearly all new industrial building construction seeks to utilize daylight so far as possible.

Sufficiency of light.—Any lighting method, natural or artificial, must take into account three factors: sufficiency, continuity, and diffusion. There must first of all be adequate window space. In general there are three ways in which window space can be provided—by side windows, by skylights and glass roofs, and by the saw-tooth roof construction. In the most modern plants these three means are combined and modified, according to local conditions, to secure the maximum amount of daylight. Some authorities say that the window area should be at least 10 percent of the floor area served, 20 to 30 percent being generally considered more desirable. Modern practice, however, tends to provide as much window space as is consistent with the supporting strength of the walls.

[10] Illuminating Engineering Society, "Glare from Type," in its *Transactions*, XXXI (March, 1936), 285.

FIGURE 28

LOADING PLATFORM

This platform is well lighted by large windows and skylights when daylight is available and by well-planned artificial lights during the darker hours.

Continuity.—Even in the plant which is constructed so as to use daylight to the fullest possible extent for all the time it is available during working hours, there are two conditions which make necessary the installation of an adequate system of artificial illumination: (1) the short period of daylight during the winter months, especially in northern latitudes; (2) the cloudy and stormy days which decrease natural light to such an extent that work cannot be carried on without eyestrain.

A condition which must be guarded against in using daylight, especially from any but a northern exposure, is excessive illumination or brightness due to direct sunshine. In midsummer the intensity of sunlight may be as high as 10,000 foot-candles outdoors and 200 foot-candles just inside a window.[11] When such a condition exists, means must be provided for diffusing the excessively bright daylight by use of diffusing glass or translucent shades or by redirecting the light so as to distribute it more evenly in the room by use of refracting or prismatic glass. In general it is advisable to have shades which may be raised from the bottom or the middle of the window. This makes it possible to provide sufficient illumination for the interior of the room and at the same time to remove the objectionable direct sunlight from the plane of vision of workmen located near the windows. When practicable, shades should be mounted so as to permit the covering of any desired part of the window. Under certain circumstances Venetian-type blinds are very effective; in other cases translucent shades are more advantageous.

Adjustment of window shades or other devices should not be left to the workers who are nearest the windows, but should be controlled by the room foreman. He should readjust the window equipment for the varying daylight conditions, and he should decide when artificial light should be used to make up for a deficiency in daylight in any location. In most modern plants all this is effected automatically by photo-electric cell controls.

Maintenance.—Clean windows are essential to proper utilization of natural light, and this simple rule of good housekeeping will go far toward solving the lighting problem in many plants. In plants having extensive window space, but inadequate window-cleaning service, accumulated dust, grease, and grime on window panes may cut natural illumination almost to zero—so that it is necessary during practically all hours of the day to resort to artificial light. The cleaning of luminaires and of light bulbs themselves is equally important.

[11] Dates, "A New Approach to Industrial Lighting Problems," *Electrical Engineering*, LVI (May, 1937), 545.

The fact that light is a factor which increases the efficiency and safety of every other tool is fully appreciated by progressive designers and owners of modern industrial plants. It is not uncommon to build track systems for window washers' trucks upon roofs and walls of factories so as to facilitate window and skylight washing.

An example may be cited which shows the importance placed on clean windows by progressive industries: in a steel plant in Pennsylvania, $50,000 was spent for construction of a window washers' railway system immediately under the glass roof of the plant. This is a far cry from the grimy smoke-filled steel mill of earlier years, which, however, has not altogether disappeared.

The proper and adequate maintenance of equipment is essential for both natural and artificial lighting. Systems which are adequate when first installed will soon deteriorate unless properly maintained. The factory owner should establish a regular, definite system of maintenance so as to insure that skylights, side windows, lamps, and accessories are at all times kept clean, in proper adjustment, and in good repair. The recommended method of establishing a suitable maintenance schedule for the cleaning of lighting equipment is to check the illumination periodically with a light meter. When the illumination has decreased to 75 percent of its initial value, the lighting equipment should be washed with a detergent (without free alkali) and warm water. Frequently a group-replacement plan of relamping can be established to coincide with the cleaning period, with a resultant saving in maintenance costs.[12]

To secure the proper diffusion of light in the work rooms, attention must be given also to interior painting. In general ceilings and the upper portions of walls should be as light in color as practicable, and should have a dull finish. The nature of many industries is such that the interior decoration should be cleaned or renewed at frequent intervals. Dirt and smoke can soon decrease the illumination not only through deposits on windows but likewise on ceilings and walls.

[12] Illuminating Engineering Society, *Recommended Practice of Industrial Lighting*, p. 27.

NEW DEVELOPMENTS IN MODERN LIGHTING

In response to the ever-increasing demand of industry for cheaper and better lighting modern science has made great strides in perfecting the incandescent lamp, in developing new types of light units, in creating new reflecting and transmitting materials, and in designing new lighting systems. The incandescent lamp, made now with tempered glass, is stronger and more heat-resistant than ordinary glass, and is smaller, cheaper, and less breakable. A new filament screen has been developed for incandescent lamps, lessening the amount of blackening that develops on the bulb, thereby increasing its efficiency.

Electric discharge lamps—neon for signs and display, mercury for industrial and street lighting, and sodium for street lighting—in recent years have come commonly into use. Generally speaking they are more efficient in transforming electrical energy into light than are incandescent lamps. The light which they produce, being of unusual and more-or-less-spectacular colors, limits their application to certain purposes for which such light is appropriate. They are being extensively applied. One company, for example, having electrical furnace operations, reports two instances in which the substitution of mercury-tube lamps for incandescent lamps was found to have a highly beneficial effect on the performance of workers and to increase production and decrease ill effects due to eyestrain.

In the graphite department of one of the company's foundries, where black and absorbent material is involved, the light from incandescent lamps was found to be ineffective. The safety director of this company reports that mercury lamps were installed, resulting in the evident satisfaction of the operators, who became more effective in their work and greatly increased the production of the department. In the foundry department the intense glare of the arc of the electro-metallurgical furnaces and of the molten metal, and the ordinary high-set powerful electric lights, caused considerable stumbling hazards, as well as eyestrain, among workers. This was particularly true when the workers were re-

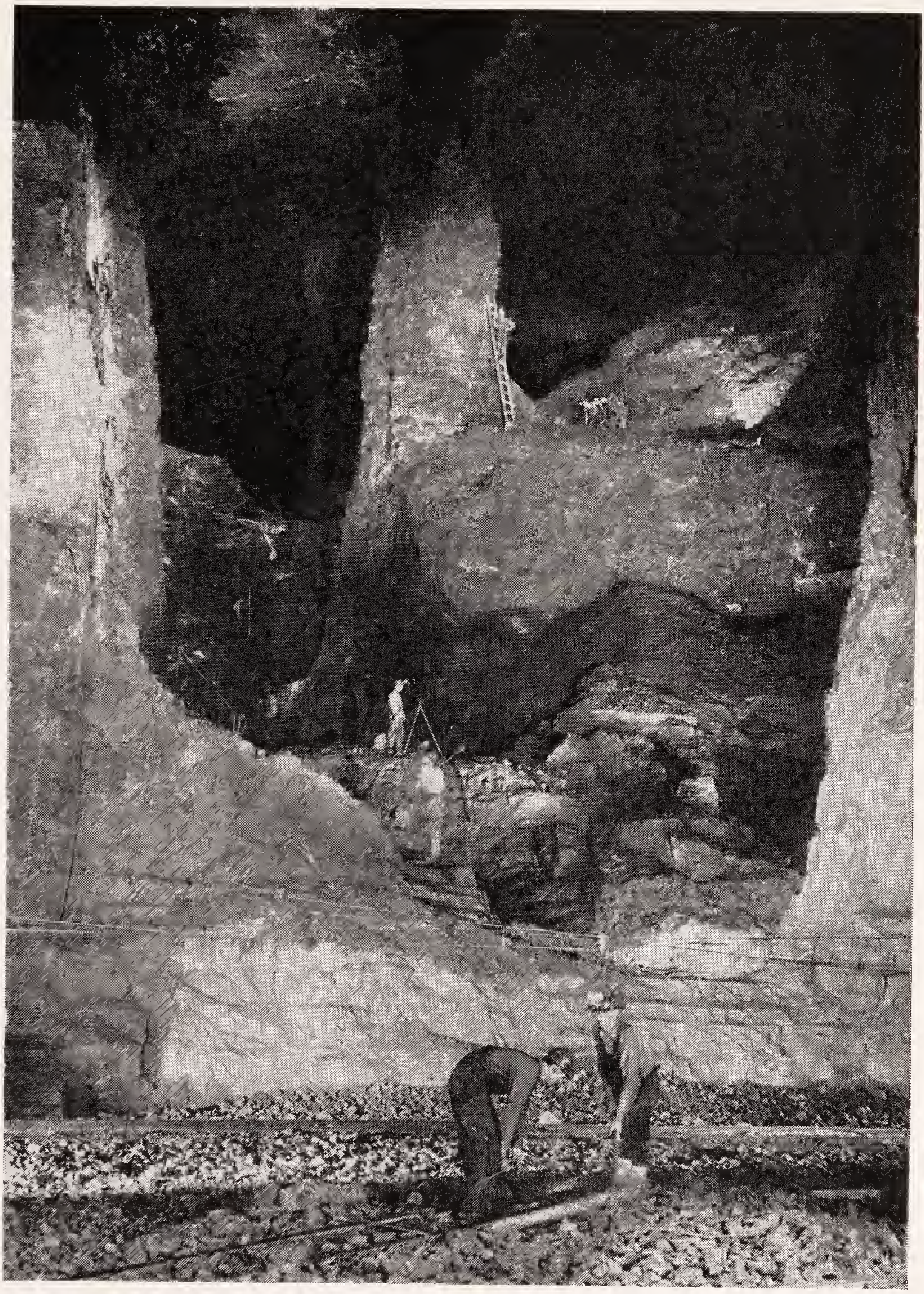

Figure 29

FLOOD-LIGHTING FOR MINE ILLUMINATION

quired to look through the small gates in the molds during the pouring operations. Mercury-tube lights, the safety director says, eliminated most of this trouble.

The fluorescent lamp is the most important recent development in electric lighting. This is a mercury-vapor lamp, but the inside of the tube is coated with powders which fluoresce under the stimulus of the ultraviolet radiation from the mercury arc. Producing in the several approaches to white light some three times as much light per watt as do incandescent lamps, they have attracted into the lighting field producers and sellers who have no experience in the complicated art of illumination. The result is that numerous installations, which in competent hands might have utilized this improved light-producing efficiency to provide light that would be eminently satisfactory, have given very unsatisfactory results. Best advice seems to be that those contemplating use of fluorescent lamps should secure guidance from thoroughly competent illuminating engineers and should make sure that all the facts are ascertained concerning light flicker, suppression and color of light, as well as ultimate costs. This advice, good in any case, is urgent in the case of fluorescent lighting, because unsatisfactory results occur when, as is so often the case, fluorescent lighting is installed under incompetent auspices.

Recent years have seen greater development of flood-lighting lamps in industries which occupy large areas, such as foundries; structural-steel manufacture, assembly, and erection; railroad yards; mines; and so forth. The use of flood-lighting in underground mines seems to have had a very good effect in the reduction of accidents and of nystagmus, a serious eye disease frequently found among coal miners.

Chapter IX

ELIMINATING EYE HAZARDS THROUGH EDUCATION

THE GREATEST possibilities for eliminating the eye hazards of industry, or—at least—for protecting workmen against the results of these hazards, still lie in education. The need is equally great with respect to the education of the employer and of his representatives, the managerial and supervisory force; education of the employee, individually and in his group (whether that be labor union, factory shift, or his family circle); and education of the State, including the legislators who write its laws, the administrators who have responsibility for enforcing them, and the general public. Public opinion influences the kind of laws that are enacted, the kind of administration these laws get, and the extent to which the worker coöperates with his employer and the State in the effort to make his occupation safe for life, limb, and sight.

EDUCATION OF THE EMPLOYER

On one point there is universal agreement among persons professionally concerned with industrial safety. This is stated repeatedly in speeches, articles, conferences, and private conversations in a variety of ways: "safety must come from the top down"; "any plant is as safe as its general manager"; "you must sell safety to the big boss if you are going to get anywhere." In no respect is this more true than in the case of eye hazards.

It is, however, no simple matter to accomplish this result. The reason is, not that industrial executives are less humane than others, but that owners and managers of industrial properties are primarily concerned with other matters—with production, sale, and distribution of certain specific commodities or services, such as coal, steel, shoes, automobiles, building construction, and chemicals. Employers are concerned with competition—competition as to price, volume, quality, advertising, distribution, and design. The average executive feels that these are matters which affect the very life of his business; they present problems which determine whether he remains in business at all. Then there are forced upon him still other inescapable problems: labor relations, business cycles, changing markets, taxes, and wars. In the face of these burdensome and usually challenging problems, accident prevention and the health protection of employees seem less important.

Most significant of all is the fact that the hard-pressed factory owner or executive can, he believes, with one flourish of his pen get rid of this whole problem by the simple expedient of buying casualty insurance or setting up his own self-insurance fund. The urge to adopt this relatively simple method of solving one problem (and so to be free to grapple with others not so easily disposed of) becomes more tempting when the owner or executive believes that in buying insurance or setting up his own insurance scheme he is getting not only financial protection against the consequences of accidents but an effective accident-prevention program as well. Thus (he reasons) he is relieved of both financial liability and moral responsibility; the cost of casualty insurance can be incorporated into general production costs and passed on to the consumer, as it is in the plants of his competitors, and (he hopes) everything that can be done to prevent accidents will be done because it is to the interest of his insurance underwriter or his own insurance department to cut accident costs. That, in general, is what passes through the mind and enters into the office routine of perhaps nine industrial executives out of ten.

There is no doubt that workmen's compensation laws and the

accident costs they impose on industry have been the most potent influences for accident prevention in America, and so, to a certain extent, the reasoning and the hopes of our theoretically average executive are justified. Frequently, however, this responsible executive, after many years of little or no personal concern over the accident and health situation of the workers under his jurisdiction, is shocked out of his feeling of security and satisfaction. Sometimes it is a steadily rising insurance rate, reaching as high as $65 per $100 of the pay roll[1] that makes the executive realize that the accident problem has not been solved in his plant; sometimes it is the death or the blinding of an old friend among his workmen; sometimes it is the appearance on the scene of a person with the courage and the ability to acquaint the executive with the facts about the accident situation in his own plant and the more favorable situation in other plants that causes the executive to become for the first time sincerely and intelligently interested in the problem and as determined to solve it as to solve the problems of production, sales, and distribution. Chief among these facts—which are still unknown to many of the important industrial executives of America—are:

1. The cost of accidents and industrial diseases is far greater than appears on the books of the company—usually five times as great as the workmen's compensation awards or insurance premiums would lead one to suppose.
2. Nearly all industrial injuries in general and eye accidents in particular are preventable; scientific studies indicate that 98 percent of all accidents are avoidable.[2]
3. Scores of plants, including properties which for many years previously had bad accident experience, have succeeded in eliminating serious eye injuries and a number in a variety of industries have operated for more than 5,000,000 man-hours each without a disabling accident of any sort.
4. The methods of accomplishing such good results are not trade secrets; they are well known by experts, easily ascertainable if not known, and applicable to any industry.
5. In nearly every case the investment made in any sincerely con-

[1] Building demolition in New York State.
[2] Heinrich, *Industrial Accident Prevention.*

ceived and competently executed safety program has paid big dividends, often better dividends than a like investment in the primary business of the company.

6. Safety cannot be secured in any plant by any one simple expedient, such as giving an order, authorizing an allocation of funds, setting up a safety department, or appointing a safety engineer. The chief executive who wishes to discharge his financial responsibility to the stockholders of his company and his moral or personal responsibility for safeguarding the eyes, life, and limbs of the men and women who work for him must do all these things—that is, he must give the order, provide the funds, and make the personnel appointments necessary for an effective safety program; but in addition, he must, through consistent personal participation in this program, make it clear to executives, subexecutives and workmen throughout the company that he really "means business."

The recommendations in item 6 are necessary because workmen, foremen, superintendents, and plant managers throughout industry are accustomed to seeing executives open spectacular safety campaigns with an avowal of determination to "make this plant as safe as is humanly possible" and then complacently to watch the campaign dissipate into a mere paper program or into complete oblivion; they have seen safety equipment installed and then allowed to deteriorate and be junked without replacement; they have seen safety orders issued and after a time lapse into oblivion—until the next bad accident; they have seen safety committees created and after a few enthusiastic meetings die of inaction and inattention; they have seen safety engineers appointed and invested with "full authority," and after a brief honeymoon of coöperation from foremen, superintendents, and managers they have seen these same safety engineers shorn of any real authority or blocked at every turn by executives and subexecutives who felt that accident prevention and health protection interfered with production, distribution, service, or sales and knew that they could ignore safety considerations with "immunity."

Where any such conditions exist or are expected because of like experience elsewhere, safety education is futile—if not impossible—unless the chief executive lets it be known in unmistakable

terms that he places safety on a par with any other interest in the plant and continues to demonstrate this determination in one way or another at frequent intervals. Many executives have done this, and in their plants a workman, foreman, or manager would be no more likely to block or to ignore any phase of the safety program than he would to ignore or to interfere with the production, distribution, or sales process. In such plants education is as much a force for eye protection as are mechanical guards, process revision, engineering, or rules and regulations.

The accident records of every industrial state, however, testify to the fact that in most American industries safety has not yet become a definite factor in the manufacturing process and that where it has been set up as a separate activity its importance has not yet been accepted as equal to that of any other phase of the plant's work. The situation in the thousands of plants where prevention of accidents and protection of the health of workers are looked upon as of secondary importance was most aptly described some years ago by Charles P. Tolman, then president of the National Safety Council and chief engineer as well as chairman of the Manufacturing Committee of the National Lead Company; he said:

> Usually the engineer is required to make the plant as safe as possible with the following stipulations: he must not interrupt operations; he must do nothing which would decrease output or increase cost; he must not make changes of a character or in a manner to cause labor trouble; he must not make changes which will affect the character of the product; otherwise he has a free rein. This seems to leave little chance for accomplishments. But hundreds of engineers are doing effective safety work under just such restrictions.

As Mr. Tolman implies, thousands of other safety engineers are, because of this situation, unable to apply fully the knowledge they have of accident-prevention and health-protection methods which have demonstrated their effectiveness in other plants in the same industry. As a consequence men and women in these thousands of plants needlessly lose all or part of their sight; workers are other-

wise needlessly injured or killed; and the huge total cost of \$3,300,000,000 for accidents[3] is rolled up annually, 98 percent of it preventable waste.

How to educate the employer.—Who can best educate the employer (and his representatives, the supervisory and administrative executives) and how this education is to be accomplished still are moot questions. Today, as twenty-five years ago, a safety conference program is rarely drafted without assigning one or more sessions to a discussion of this problem. The difficulty is twofold: (1) employers, like employees, differ widely, and consequently there is no one best method of getting and retaining their interest and effecting the necessary education; (2) more important, employers, unlike employees, are not readily available for the educational process, nor are they very susceptible. The employer, owner, manager, boss, executive—call him what you will—usually is a man who "has arrived." He is successful, and frequently "self-made." In matters of his business he is accustomed to tell—not to be told—except, perhaps by other executives or associates of higher or equal authority. Least of all is he, as a rule, inclined to lend a ready ear to a government official or employee. Unfortunately the executives of other companies and associates in his own company who do have access to him are not ordinarily aware of the facts (previously mentioned) which are prerequisite for the safety education of the employer; those who may be aware of some of these facts usually are far more concerned with other aspects of the business when they are in conference with him.

The persons who do know the situation with respect to occupational health and accident hazards in particular industrial properties and what can be done to eliminate those hazards seldom have access to high executives. Too often such persons lack the ability to do the necessary educational job if they do reach an important executive. Frequently they are state factory inspectors or insurance company inspectors. Sometimes the man who is known as "safety engineer" and who nominally has responsibility for the

[3] National Safety Council, *Accident Facts,* 1940, p. 62.

duties which that title implies is actually a claims settler, a master mechanic with a flair for designing safety devices, or a personnel clerk, with many other duties besides accident prevention. Such persons are usually responsible to a subexecutive several steps below any of the top officials. Under such circumstances to break through inertia, tradition, organization procedure, vested interests, and the opposition of foremen, superintendents, department managers, who fear that their own problems will be aggravated, requires more gumption, personality, persuasiveness, and sales ability than most persons in these positions usually have.

The history of the safety movement is, nevertheless, replete with stories concerning industrial executives who, in one way or another acquired a vital interest in safety which brought about the coöperation of supervisors and the rank and file of workers alike. Among the most outstanding of these was the late Elbert H. Gary, head of the United States Steel Corporation. Quite indirectly Judge Gary probably did more than any other one man to advance the safety movement in America. This was so because long before Judge Gary was publicized as "the father of the safety movement" he, personnally, and the Steel Corporation were generally recognized by other industrial executives as leading exponents of the art of "good business."

At the time when the Steel Corporation was spending a million dollars a year for accident prevention, health protection, and general welfare activities, Judge Gary told the writer he believed the corporation received bigger dividends from this investment than from the investment of a million dollars in the direct process of steel making. In the first ten years of its safety program the Steel Corporation reduced eye injuries 86 percent and many other types of accidental injuries proportionately. The fact that this group of companies—operating not only steel mills but also coal mines, railroads, steamship lines, and fabricating plants—were making such a big investment in accident prevention did as much as anything else to develop an interest in safety among the executives of other companies, who frankly said: "If the Steel Corporation finds safety a good investment, we'll invest in it too."

Today concrete evidence concerning the economic value of accident prevention and health promotion still is effective in persuading industrial executives. Even more effective under many circumstances is evidence that safety and efficiency are interdependent. Evidence that certain other concerns, competitors, and neighbors have better safety records will also do much to get certain executives seriously interested in thoroughgoing safety measures. Human nature being what it is among industrial executives, as well as among the population in general, still other influences often play an important part in the difficult task of "educating" or "selling" executives the idea that genuine personal concern with safety is of value.

Thus, local pride, the ambition to rank an industry, and the desire for favorable publicity, good public opinion, and public honors often do more to incite and to preserve in an executive, interest in the safety program than does the chance to save some money for the company by reducing casualty insurance rates. A safety award, whether it is a gold medal presented to the president of a company under the glare of klieg lights and in front of microphones or an inexpensive felt banner awarded to a grimy foreman of a section of a department, may be far more important than the traditional interest in the "almighty dollar" as a means of stimulating industrial safety work.

No one formula can be offered for educating the employer or for "selling the big boss" on safety. Earlier chapters of this volume present facts which should be helpful in the process. The technique of educating the executive must vary with the special circumstances surrounding his plant, his personality, and the accident experience of his company. Sometimes the person who can do this job best is the executive himself. In such cases all that may be necessary is to place the facts with respect to his own company and other industries before him at the right time. At the other end of the scale is the executive, now very much in the minority, who is so disinterested in the conditions under which his employees work that only legal compulsion will move him to make his plant safe. Because of the survival of this type the time may come

when public opinion, outraged by another horrible and needless industrial disaster, will force legislation to hold the employer personally responsible when through criminal negligence a worker in his plant is killed or maimed.

EDUCATION OF EMPLOYEES

Education of the employer with respect to safety may be difficult, but once it is accomplished there is seldom occasion to repeat the process. The reverse is true with respect to the safety education of employees in factories, shops, mills, mines, and other industrial work places. Workers are constantly subjected to situations, personal and occupational, which invite at least momentary disregard for safety; and in the case of eye hazards, a momentary lapse from safe practices may lead to total blindness throughout life or to other serious permanent injury. Safety education of the worker therefore needs to be continuous and frequently infused with new life.

It is futile to expect good results from any program for the safety education of employees until after the management has demonstrated its own sincere and serious interest by making the plant physically safe. This calls for provision of all necessary guards, goggles, head masks, shields, and other protective devices. Where proper lighting and good general housekeeping are not already the rule, adequate steps toward their provision must be taken. It is necessary to take advantage of all obvious opportunities for eliminating hazards through process revision. And some sort of permanent safety organization must be set up or steps must be taken to incorporate safety into the general plant organization if for any reason it is not desired to create a separate safety department.

It is, of course, perfectly proper to undertake several or all of these activities more or less simultaneously with the launching of a program for safety education of the workers. The experience of many concerns, however, points to the fact that only when workers see evidences of the company's genuine interest do they become fully receptive to the program of education intended for

FIGURE 30

DRIVING AN EIGHT-PENNY NAIL INTO A BLOCK OF WOOD WITH A PAIR OF SAFETY GOGGLES

This gives convincing evidence of the strength of goggle lenses.

them. Of course, not all these measures can be accomplished over night; it often requires months or years to make substantial progress in all these respects in a particular plant. It is essential, however, for management to demonstrate to employees its own conversion to the safety program and its intention to do all that management can do for accident prevention before it can expect

the full coöperation of its employees and their receptivity to safety education.

Who should educate employees.—The person who can most effectively do the job of safety education and the methods to be used depends largely on the different situations existing in different plants. The safety engineer, the personnel or employment manager, the plant doctor, the nurse, and the foreman—each has opportunity to play an important part. Of all these, the foreman is the most important.

As is true of all job training, safety education of the worker, can be more effectively accomplished by the foreman than by any other person in the plant. This is so for a number of reasons. The foreman has greater opportunity than any other person to observe the work habits of an employee; he has a better chance to understand the physical and mental makeup of the employee, his home life, and the factors which influence him. In many plants the foreman is "the company" to the men under him—the only representative of the management with whom they have contact. Often the foreman is practically a dictator in his own department, as long as he produces results satisfactory to the management. For all these reasons the foreman should be the first to receive safety education, and the whole program of the safety education of employees may well revolve about him.

Training the new employee.—Ideally, safety education of an industrial worker begins before he actually goes to work—during the employment interview, which is one of the most strategic moments in the safety education of an industrial worker if he feels that the decision as to his employment depends, in part at least, upon whether he is or can become a safe worker. Then is the time to point out to the applicant the fact that an unsafe worker cannot be an efficient worker and that an employee who is involved in accidents—whether or not they result in personal injury—slows up production, increases overhead costs, and interferes with plant efficiency in general.

One large company with shops in various parts of the country makes it a practice to say to each person who is considered for

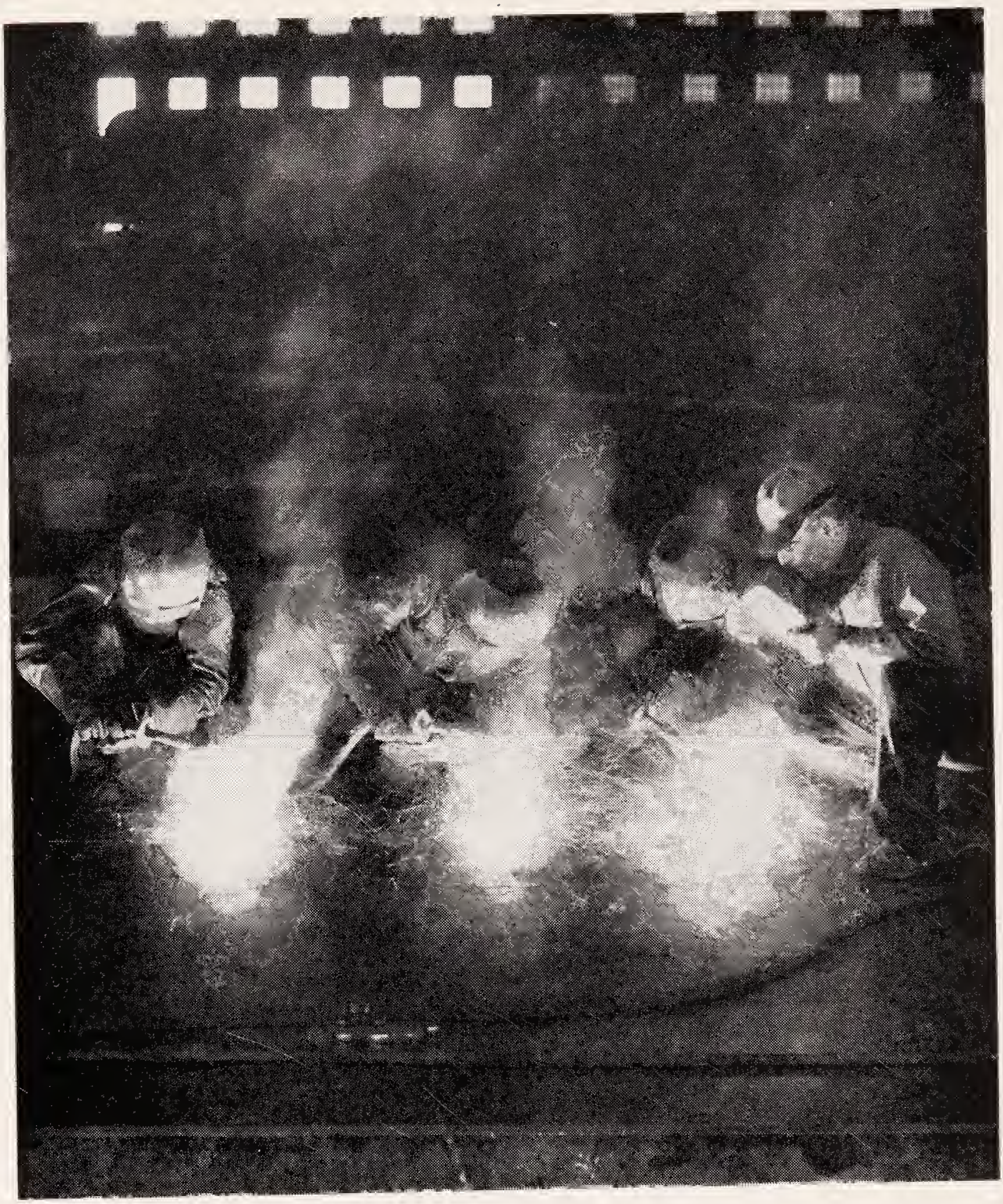

FIGURE 31

CLASS OF APPRENTICE WELDERS AND THEIR SUPERVISOR

Eye protection is afforded by hoods for the apprentices and by a hand mask for the instructor.

employment: "If you go to work for us you must wear goggles all the time you are in the plant, no matter what the nature of your work; if you won't wear goggles all the time, you can't work here." Some few men and women have refused to take employment in this company under these conditions. On the other hand, this statement at the time a worker is employed contributes much to the unusually fine record for the prevention of eye injuries which this company has maintained for more than a decade.

In many concerns it is common practice to initiate training by conducting the new employee on a tour of the plant during which the various departments, processes, and products are explained. Along with these explanations he should be given a clear picture of the hazards that may be encountered and the devices or methods which are employed to avoid them. When the tour is completed and when the new man has been informed about such routine matters as working hours and plant regulations, the actual job training begins.

Some production managers take the position that safety and production efficiency are one and the same thing and that there is, accordingly, no need for safety training apart from training for whatever work the new employee is to do. There is much justification for this point of view when it is honestly held. In some industrial plants, however, the position that safety and general efficiency are identical is taken merely as an excuse for avoiding the installation of a safety engineer or a safety department.

Whether safety education is carried on by a safety department or by the production department or by some other unit is not important. What is important is that whatever individual or unit is responsible for safety education shall be invested with proper authority and shall be thoroughly competent and that safety education be well-planned and organized as a permanent activity, not as a frill or emergency "shot in the arm" to satisfy a disgruntled insurance underwriter or the whim of someone else.

When no training school is maintained by the company and the responsibility for training devolves principally on the foreman, the safety engineer or whoever may be in charge of accident

prevention should make sure that eye-accident hazards and occupational-disease hazards which may involve the eyes are pointed out to the new worker and that he is instructed in all known means of guarding himself against these hazards. It should be the duty of the safety engineer, when one is in the plant, to secure from outside sources (such as safety councils, government departments, insurance underwriters, and health-promotion agencies) all available data concerning elimination of these hazards and the protection of workers against them and to give the foreman or whoever is responsible for training new employees all possible assistance in laying before them the information that may help them avoid injury.

For reasons elaborated elsewhere in this book it is especially important that new employees be informed as to any poisonous substances or fumes to which they may be exposed and the precautions they should take. A word of caution at the beginning of his employment may eventually save the worker from going blind and, just as likely, save the company from a serious damage suit and heavy compensation payment.

Educating the old employee.—In the first ten or fifteen years of the safety movement education of old-fashioned, so-called "hard-boiled" employees presented one of the most troublesome problems confronting the safety engineer. Not only was it difficult to get these oldtimers to change their work habits and to wear goggles but also their open refusal or their only-slightly-concealed disregard for the new devices and methods made the problem of safety education of apprentices and other young workers more difficult than it would otherwise have been. This situation has, however, changed. Those of the older workers who were once known as "hard-boiled" in matters of safety have finally succumbed either because they have been so long exposed to safety propaganda or through fear of losing their job, knowing how difficult it is for older workers to secure new employment. Whether for these reasons or for other reasons, the phenomenon of the stubborn employee who refuses to help safeguard his own life and the lives of fellow workers is becoming rarer every day.

Nevertheless the experience of many industrial concerns indicates that a disproportionately large number of accidents still involve experienced employees. In the Fairbanks-Morse Company of Beloit, Wisconsin, for example, during a recent period of study,[4] 52 percent of all accidents involved only 38 percent of the employees—those who had been employed for more than five years.

Why should experienced employees in plants where safety is emphasized be involved in so many accidents? Why should men who have been employed for many years in a "safety conscious" plant and who should therefore also be "safety conscious" be more prone to accidents than comparatively inexperienced employees? The answers to these questions may be stated as follows:

1. Negligence with regard to the training of experienced employees. In some plants safety education is given to new employees only. In plants where safety training is compulsory for all employees it is often the policy to discontinue the training of older workers after a short time so as to concentrate on the training of newer employees. In plants in which training is left to the discretion of the employee himself the experienced worker often feels that he has had enough safety training. In such cases, when training has stopped and when the monotonous routine of a job has relaxed the employee's vigilance against hazards, accidents occur in spite of years of experience. Certain workers who do the same job for several years no longer concentrate on their work; they can perform any operation, no matter how hazardous, almost automatically. Therefore they become a serious accident hazard to themselves and to their fellow workers. Such a situation can be remedied by constant but frequently varied safety training for all employees. The older employee can continue his training by supervising the training of a younger employee or by serving as inspector or member of a safety committee. Whenever possible, work assignments should be changed occasionally to avoid the monotony which may lead to automatic and hazardous work.

2. The physical condition of old employees. One of the most common—and sometimes least suspected—causes of accidents involving old employees is some unknown physical defect. Defective eyes, flat feet, arthritis, heart trouble, infected teeth, rheumatism—any one of these

[4] Cox, "Teaching Old Dogs New Tricks," *National Safety News*, XXXIV (July, 1936), 23.

afflictions or a score of others may be the underlying cause of an accident. The obvious preventive measure for such accidents is periodic thorough health examinations. It is necessary, in addition, to educate employees—especially the older employees who because of fear or ignorance, object to such examinations—to a realization of the benefits to be derived from early discovery of bodily ailments. The friendly and sympathetic coöperation of foremen, doctors, and nurses in discovering such ailments—and of the plant management in supplying treatment or otherwise facilitating it—can do much to eliminate accidents caused by poor physical condition.

3. Resistance to change or innovation. While it is true that most persons object, consciously or unconsciously, to change of routine which tends to break old habits, such resistance is usually stronger among older persons. The old-fashioned "hard-boiled" employee who objects to the use of safety appliances and safe practices is usually an elderly man who, as he might put it, "has gotten along all right without any newfangled safety gadgets" for twenty, thirty, or forty years, and doesn't see why he should change now. Such an employee will often agree that safety devices and safe practices have merit, but he will attempt to excuse himself from them on the grounds that he has been in the trade too long to change.

The problem of educating such change-resistant employees to recognize the values of and to coöperate with a safety program is often complicated by circumstances peculiar to the individual plant. Occasionally the recalcitrant employees are able to disregard safety regulations because they are "privileged characters" —either because of superior and in some cases indispensable skill, because of special union affiliations, or because of some other strategic position in the plant organization. These "privileged characters" are the very men on whom educational attacks should be centered. If a man's ability is such that replacing him would be difficult or impossible, it is all the more important that he be taught to work safely. If a man has influence or authority over his fellow employees because of union affiliations or for some other reason, it is important that he, too, be taught to work safely.

The method of training experienced workers for safety must vary from plant to plant. In general it has been found most effective to train the foremen, who in turn train the men under them.

In many instances, however, voluntary training is preferable. The employees of any plant are more likely to benefit from a training course they attend because they believe it will improve their work and enable them to earn more money than from a training course they are forced to attend because of plant regulations.

THE ACCIDENT-PRONE EMPLOYEE

In every plant there are some employees who are involved in accidents more often than others engaged in the same kind of work. This is sometimes true of employees who are not involved in particularly hazardous operations. There may be nothing in the attitude of these employees to indicate careless habits which might lead to accidents, yet in spite of every precaution accidents continue, though not always causing personal injury. Such men, who seem to be definitely accident-prone, present a baffling problem.

In one of the few surveys of the accident-prone employee[5] 50 electric railway motormen with abnormally high accident rates were examined carefully for characteristics which might be conducive to accident proneness. They were observed in all phases of their work; their accident records, with circumstances, apparent causes, and contributory elements, were studied; a personal interview was made in each case to determine outside influences which might affect the high accident rates. At the conclusion of the investigation an attempt was made to classify the causes of "accident proneness," though it was recognized that each case was different from the others. "Faulty attitude" was found to be the principal causative factor in 14 percent of the cases studied. "Failure to recognize potential hazards" was responsible for 12 percent of the cases, and "faulty judgment of speed or distance" was responsible for another 12 percent. It is interesting to note that "inexperience" was responsible for only 2 percent of the cases studied. The other causes of "accident proneness" reported as a

[5] Metropolitan Life Insurance Company, "The Accident-Prone Employee; a Study of Electric Railway Operation Undertaken by The Cleveland Railway Company with the Coöperation of Policyholders Service Bureau."

result of this study were: impulsiveness, irresponsibility, failure to keep attention constant, nervousness and fear, defective vision, organic disease, slow reaction, high blood pressure, senility, worry and depression, fatigability.

No two cases were found to be similar. While 14 percent of the cases were due to "faulty attitude," each worker's faulty attitude was caused by a different set of factors and manifested itself in a different way. One motorman who handled his car satisfactorily under normal conditions became indifferent to his responsibilities whenever he was late because of traffic delay. Another had a hostile attitude toward pedestrians and vehicular traffic. In some cases the high accident rate could be traced to domestic troubles, to poor physical condition, or to some personality trait.

Having discovered these causes, the companies set out to eliminate them. Treatment varied, but each man was given a general physical examination, including an eye examination, with treatments depending on the conditions found. Motormen with operation defects were retrained; others were transferred to conducting or supervisory positions, and in a few cases the men were discharged. The results of the survey were gratifying in that every motorman who was examined and treated showed improvement, and some made a substantial reduction in their accident rate.

While this survey threw little light on any basic universal causes of accident proneness, it did focus attention on the factors which play an important part in causing accidents. Low intelligence, immaturity, hostility toward fellow workers, bosses, or outsiders, and unhappy home life affect accident rates just as much as poor physical condition and poor operating technique—factors with which safety engineers are better acquainted. Solution of the problem of accident proneness calls for thorough investigation of the causative factors. Once these factors are determined, the treatment necessary usually is quite apparent.

TRAINING METHODS

It is commonly said in safety meetings that 10 to 25 percent of all accidents can be prevented by mechanical means and that pro-

tection against the remaining percentage depends upon education. This is not true of eye injuries, which, unlike injuries to other parts of the body, are almost entirely preventable by mechanical means, as was discussed in Chapter VI. It is one thing, however, to devise goggles, head masks, and other guards that afford complete eye protection, and it is quite another thing to get employees to use these guards constantly and conscientiously. Only thoroughgoing and continual safety education will do this. Knowledge of certain basic principles of safety education may aid in the planning and the execution of training programs and techniques.

1. Educating for safety is a matter of imparting knowledge. Facts—not slogans—must be presented, facts that explain why accidents happen and what can be done to prevent them. Merely telling an employee to "be careful" won't do much good. Explaining to him exactly what the hazards are in his particular line of work and how he can protect himself against those hazards will help to prevent accidents.

2. Safety training must be simple to be effective. If you use statistics, present them in the most simple form possible so they will be understood by the least educated of your employees. If you use posters, avoid complex, crowded ones, which more often confuse than explain. In talking to workmen use a simple, blunt form of speech that will leave no doubt as to your meaning. The value of simplicity in safety education cannot be overemphasized.

3. Safety training should point out the value of safe practices *to the employee*, not to the company. In nine cases out of ten the employee has little interest in the benefits gained by the company from a "no-accident" record. The pieceworker who persistently refuses to use a guard on his machine often does so because he thinks he can thus increase his output and thereby his wage. You can't make that pieceworker safety conscious by appealing to his loyalty to the company—you must appeal to his pocketbook, his love for his family, or the security of his job; you must make him feel that his responsibility to his family is too great for him to risk endangering his wage by not working safely. "Protect your

family's income" might well be the keynote of all safety education of industrial workers.

4. Safety is primarily a habit of thinking. Training for any habit must be constant and undeviating. After the fundamental ideas are put across, it is still necessary persistently to repeat them with new variations.

Sources of educational materials.—The chief source of general safety material—statistics, posters, instruction charts, safe practices pamphlets, and so forth—is the National Safety Council, with headquarters in Chicago. Among the most valuable of the council's offerings are the safety instruction cards, which contain brief descriptions and listings of safe practices and other safety data, as for example, "Safe RPM's of Abrasive Wheels" or "Required Equipment for Welding" or "Safe Practices for Cleaning Tank Cars," to cite just three of many which should be helpful in educating for eye protection.

Good safety material is also available at the Federal and state departments of labor, casualty insurance companies, and other organizations whose activities will be described later in this chapter.

Year-round safety programs.—A common problem of industrial safety departments is constantly to keep safety in the minds of employees after they have received a "course" in safety education. As one safety engineer put it: "What is needed is not so much education as making them remember what they know." The efficient safety department will bring safety to the attention of each man personally in one way or another every day if possible. To do this the methods of presenting safety material must be constantly changed, for it is important that employees do not lose interest and become bored with safety precautions. Use of safety posters, even if changed once a week, for example, may be effective for a year or two or three, but, after ten or fifteen years of safety posters, the average employee will not so much as notice the color of the current poster, much less read its message.

Proceedings of safety conferences, files of safety magazines, and records of safety organizations are full of good ideas for keeping

interest in safety alive throughout the year, and year after year. The few examples which are presented here are merely illustrative and should not be regarded as preferable to all others. No program, no matter how enthusiastically accepted by employees,

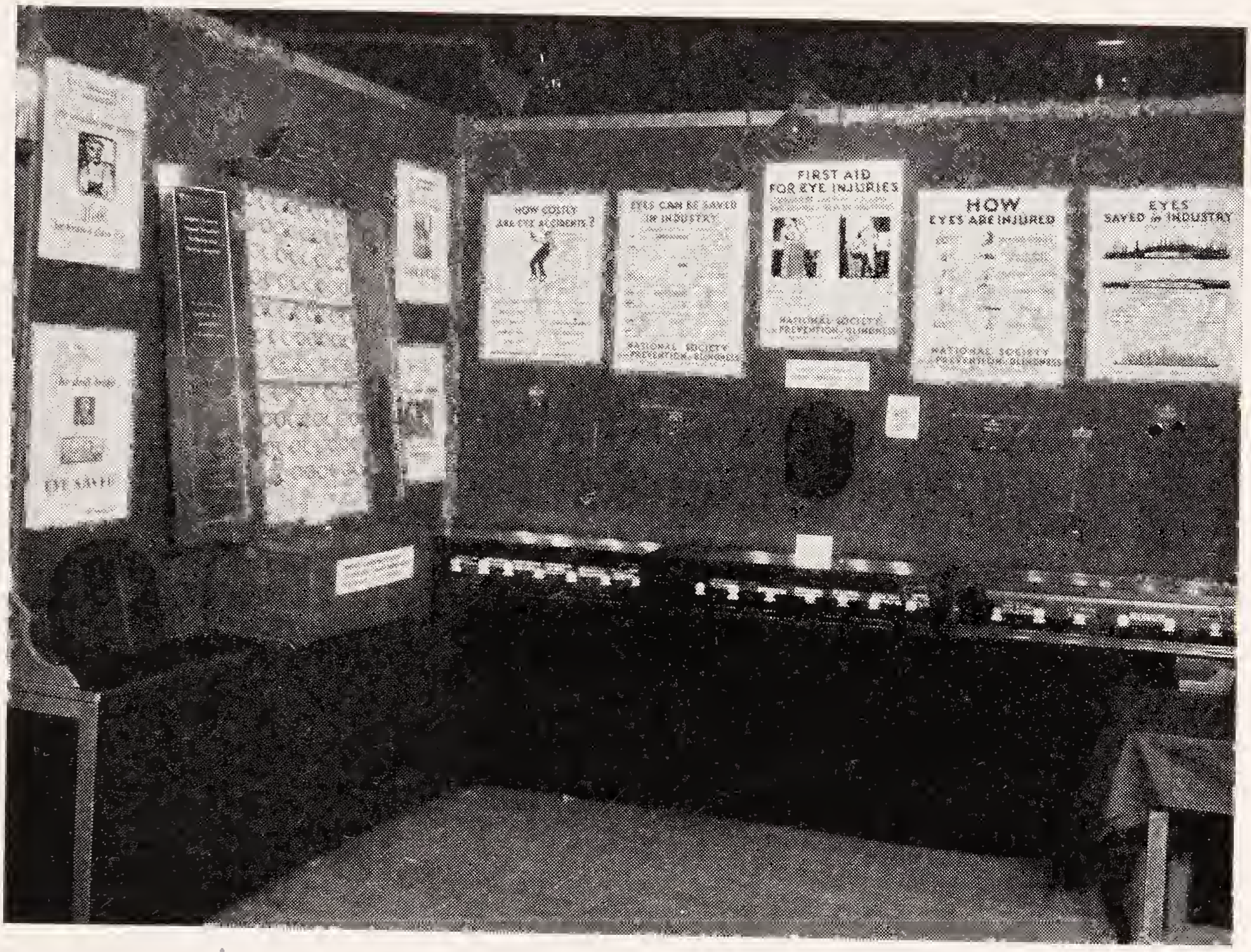

FIGURE 32

TYPICAL INDUSTRIAL EYE SAFETY EXHIBIT

should be used for too long a period; one or two years is the average useful life of the best. Constant change of program is necessary for the continued interest of employees.

Formation of safety committees having the dual purpose of stimulating active participation in safety work and of supervising safe practices is a common and usually effective technique. At the Lehigh Portland Cement Company in Birmingham, Alabama, a general safety committee[6] supervises all safety activities by means of the following subcommittees: The Fire Committee,

[6] National Safety Council, *Transactions,* 1935, p. 188.

which inspects fire apparatus and housekeeping from the point of view of fire hazards, and supervises fire drills; the Accident Committee, which places responsibility for accidents and makes recommendations for avoidance of a recurrence; the First Aid Committee, which inspects first aid, hospital, and sanitary matters; the Welfare Committee, which supervises the general welfare of employees and their families; and the Publicity Committee, which supervises bulletin boards, safety campaigns, contests, picnics, meetings, and so forth and coöperates with community safety organizations. Such a system of committees makes possible "year-'round" participation of large numbers of employees in the educational and otherwise constructive work of locating hazards and taking steps to eliminate them.

J. E. Culliney, of the Bethlehem Steel Corporation, suggests a plan by means of which a different feature of safety work is emphasized each month. While it is true that each feature mentioned should receive attention throughout the year, by emphasizing a specific group of hazards each month interest in safety in general can be maintained at a higher pitch. The plan calls for a "Safety Calendar"[7] in which the following features are emphasized each month:

January—Chain, wire and rope. All lifting materials including cranes, hoists, winches, etc. to be thoroughly examined for defects—frayed ropes, kinks in wire, weak or broken links.

February—Hand tools, including pneumatic tools. Examined for mushroomed heads, chipped cutting edges, defective handles, etc. Complete check-up of all defective tools to be discarded or reconditioned.

March—Machine guards. Inspect for rust, dirt, or other factors making for inefficient work. Inspect for guards made obsolete or ineffective because of change of location of machines or installation of new equipment.

April—Housekeeping. Inspect for poor piling, obstructed walkways, broken stair treads, defective floors, accumulation of rags, wood scraps or other flammable material.

May—Electrical equipment. Inspect motors, switches, wiring. Look

[7] Culliney, "Safety the Year 'Round," *National Safety News*, XXXVII (Jan., 1938), 12–13.

for exposed wires, exposed knife switches. Check on efficiency and effectiveness of lighting.

June—Ladders, scaffolds and lumber for building. Check quality of wood and construction.

July—Welding. Check on shields, helmets, goggles and gloves.

August—Conveyances—inspect chain falls, tackle blocks, steam shovels, department trucks, elevators.

September—Chemicals and compressed gas. Check on containers, handling methods and exhaust systems for compressed gases, acids, and other chemicals.

October—Winter hazards. Before the cold weather sets in, check on heating and ventilating equipment.

November—Personal protective equipment. Goggles, safety shoes, gloves, clothing. Check for effectiveness, adjustments and replacements.

December—Plan for next year. Develop safety organization and activities for the following year.

Other year-'round activities which stimulate interest in safety and contribute toward a reduction of eye injuries are:

Interdepartmental and inter-plant safety contests with prizes for the best safety records; preparation of safety rule books for employees and foremen, and drawings and specifications for standard equipment; safety lectures, exhibits, moving pictures, safety museums, and "bad-tool morgues"; safety departments in plant publications; pay envelope inserts of safety slogans and sermonettes; warning signs and lights; blackboard messages, frequently changed; language instruction (failure to understand instructions or inability to read warning signs printed in English is frequently the cause of serious accidental injury to foreign workmen); and use of special bulletin boards to indicate progress in campaigns (such as: a "bowling" scoreboard in which each no-accident day is a "strike"; a railroad track with toy cars moving one tie ahead each no-accident day; a race track with a horse for each department; and safety thermometers to show the rise of a no-accident record).

Safety stunts.—There is not now among those professionally concerned with accident prevention the interest in safety stunts and safety slogans that characterized the early years of the safety movement. This is due to a growing recognition of the fact that what is spectacular is not always effective in safety education.

There is, nevertheless, in industrial safety education—as in any other form of mass education—a proper place for the dramatic. A parade, a play, a mock trial, even a humorous skit may provide the sugar coating that enables certain workmen to swallow bitter safety pills they have long put aside.

The files of safety organizations and of safety magazines also provide an abundant source of reports of stunts, which will suggest still others suited to particular situations in almost any kind of plant. A few of the many stunts which have been tried in various plants as an added stimulus to the safety campaign follow:

A "Jinx Cat" or "White Elephant" is awarded to the department or gang having the worst accident record. This emblem is retained until another department makes a poorer showing or until every department has a no-accident record of one year.

A "Safety Broadcasting System" was devised at the Chicago and Cicero plants of the Edison General Electric Company. Broadcasting is continuous during the lunch hour. Entertainment is supplied by employee musicians and singers and is interspersed with brief talks and announcements about safety.

In another plant a Safety Bonus of $1 per month is awarded to every employee providing there is no accident during that month. This has been most effective in getting employees to supervise and reprimand fellow workers guilty of unsafe practices.

At the entrance of the Libby-Owens-Ford Glass Company at Toledo, Ohio, stands a life-size dummy of a 14-year-old boy. Whenever any employee is injured, the dummy is bandaged, indicating the injury received. A card is attached explaining who was injured, why and how. No worker likes to see his name attached to the dummy, with the result that accidents are being reduced.

Several plants use goggle carts which carry goggles, tools for repair and adjustment of goggles, and sterilization equipment. These carts travel about the plant continuously for the dual purpose of servicing goggles and other equipment for head and eye protection and carrying education concerning use of this equipment. The men who accompany the cart are trained to select proper goggles for specific operations and to repair and adjust goggles already in use.

Safety stunts can be extremely effective, but it must be remembered that they merely supplement a safety program and do not constitute such a program in themselves.

Safety education in vocational schools.—Ideally the education of industrial workers should begin even before they set out to find jobs. More than 4,000,000 boys and girls, young men and young women attend some form of vocational school or college every year. Each year approximately 800,000 of these young peo-

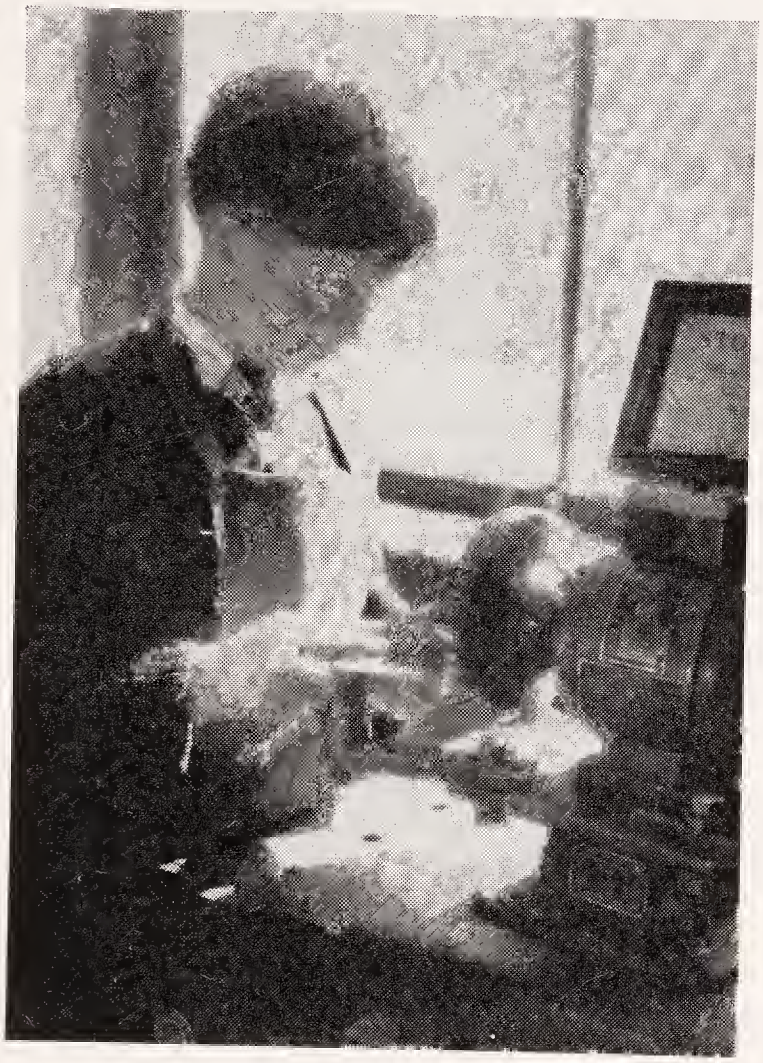

FIGURE 33

STUDENT AT EMERY WHEEL

Education in the safe practices of industry should begin in the vocational schools; because of this boy's early training in the use of goggles he will never take the chance of losing an eye at his job.

ple are graduated and begin to look for work. We have no way of knowing how many actually find jobs, but we know that most of those who do, trained as they may be in certain crafts, have had little or no training in the use of safety devices or in safe practices in the occupations in which they are employed.

Vocational schools often show less regard for the hazardous conditions found in their workrooms than do average industrial

plants. Too many machines are unguarded; use of goggles is the exception rather than the rule; shops are crowded and poorly organized; and the operating technique of students is often sloppy and careless. Safety engineers report that new employees who have had apprentice training in vocational schools not only are untrained in any aspect of industrial safety but also often have already established work habits which are definitely hazardous.

It is a strange fact that American schools, which in many ways are the most progressive in the world, are so negligent in matters of safety. Interestingly enough not one of the leading magazines concerned with vocational education has published a single article on school safety during the past five years. There are several obvious reasons for this negligence.

1. Perhaps the most important is the lack of any legislation analogous to workmen's compensation laws to put upon school management definite liability for injury to students. Most school administrators, feeling that they and the governmental units under which they operate are legally free from responsibility for accidents, are inclined to regard machine guards, goggles, and other safety equipment as unnecessary luxuries. The fallacy of this attitude is illustrated by the recent case of a New York City student who lost an eye in a school shop. A judgment of $15,000 was rendered against the Board of Education and the city. Ten thousand pairs of goggles and other safeguards could have been purchased for $15,000!

2. Another cause for the lack of safety education and equipment in vocational schools is the attitude of many instructors who seem to believe that mechanical safeguards are more dangerous than unguarded machinery. Others feel that students will be better trained if they work on unguarded machines. This idea is based on the theory that exposing students to known hazards will make them more careful when they obtain employment in industry. Still other instructors feel that the lack of the necessity for speed in school shops cancels the need for guards and safety instruction. All these opinions are ill founded and frequently a means of rationalizing the use of inadequate equipment resulting

from inadequate school budgets. An unguarded machine is just as dangerous in a school workshop as in an industrial plant.[8]

While some few vocational schools are giving appropriate attention to safety, there is no escaping the fact that in general these schools, which have a better opportunity than industry itself to form safe working habits among the industrial workers of the future, are far from taking full advantage of their opportunities and their responsibilities in this respect. Since the most effective control of safety in schools, the legislative control, will probably not be in force for some years, it is up to industry to do everything it can to instill safe habits of work in the industrial employees of the future. Plant executives and plant safety departments can do much in their respective communities to encourage adoption of safety programs in the schools. Student tours of safeguarded plants, lectures, demonstration of safety equipment by industrial safety men, support of parent-teacher associations—especially in small communities where the parents are largely employed in local plants—are a few ways in which plant managers can coöperate with the vocational schools in establishing an accident-prevention program.

Safety education by other public agencies.—Industrial safety education lies also within the province of certain government departments. State industrial commissions and state departments of labor, the United States Department of Labor, and the United States Bureau of Mines have all made important contributions in this field.

The extent and effectiveness of the supervisory activities of state factory inspection boards will be dealt with in detail in Chapter X. The educational work of factory inspectors will be touched on here. According to the Division of Labor Standards of the United States Department of Labor,[9] the educational duties of state factory inspectors are as follows:

[8] Guilbert, "Let's Put Safety into the Vocational School," *Safety Education*, XVIII (March, 1939), 198.

[9] United States Department of Labor, Division of Labor Standards, *Factory Inspection Standards and Qualifications for Factory Inspectors.*

> . . . to promote the active interest of employers and workers in the establishment of safety and health programs planned to provide safe and healthful working conditions, and the establishment of safe working practices; to act as consultant and adviser on matters of industrial safety and health to industry and to address employers' and workers' organizations. . .

Such a program of education can be extremely effective in supplementing educational activities of plant managements and in stimulating such activities in plants where little or no safety education is carried on. Indications are, however, that little educational work is being done by state inspectors. There are few really effective factory-inspection agencies in existence, and less than one-third of the states have anything approaching adequacy with respect to even routine enforcement. The prospect for the future seems promising, however, due mainly to the efforts of the recently organized State Factory Inspectors' Training Courses, sponsored by the United States Department of Labor.

Besides the work it has done to improve the caliber of state factory inspectors, the United States Department of Labor has been instrumental in establishing standards of health and safety in many industries. The long list of Department of Labor publications in which these standards are presented forms a comprehensive library of safety educational material.

For many years the United States Bureau of Mines has provided instruction for miners in first aid, artificial resuscitation, and mine rescue drills. In recent years this instruction has been extended to include workers in other industries. At present some tens of thousands of industrial employees are receiving this training every year. In some plants, Bureau of Mines' training in first aid is compulsory—instruction being given to every employee at least once a year.

Safety education by private agencies.—The greatest educational influence for the elimination of the eye hazards of industrial occupations is the general industrial safety movement. There are numerous plants where, because of several very costly eye accidents, greater attention is given to prevention of this par-

ticular type of accident than to the prevention of accidents in general. On the whole, however, the best results in the prevention of accidental injury to the eyes and in the conservation of vision through proper lighting and sanitation are found in those plants which are doing good all-'round safety work. The safety movement has been motivated principally by private agencies; for that reason it is appropriate to consider the educational work done by these agencies.

The National Safety Council.—The National Safety Council is the leading national agency in the field of accident prevention. In 28 years this coöperative, noncommercial organization has grown from a nucleus of fourteen to a membership of some 5,000.

Started as an industrial safety organization, the council almost immediately broadened the scope of its aims and activities to include every field of accident prevention. Its committee and staff organization includes departments of traffic, school, home, and farm safety. Numerous publications are issued and many conferences held on these subjects.

The members are served by a staff of more than 100 men and women professionally engaged in the direction of accident-prevention activities as well as by thousands of volunteer workers in member organizations.

The object of the National Safety Council, as expressed in its constitution, is "to promote the conservation of human life and its incidents in the industries of the nation and to that end:

(1) To establish a conveniently located headquarters for the maintenance of a clearing house of safety information, available to all concerns;

(2) To encourage and promote throughout the country the organization of those engaged or interested in safety work into districts and local councils, in affiliation with the National Safety Council;

(3) To hold Annual Congresses;

(4) To encourage and assist in the practical standardization of safety devices, safe conditions and practices;

(5) To give widest publicity, through its own publications and other channels, to all matters calculated to promote industrial safety;

(6) To initiate, promote, coöperate with and obtain the assistance

of all activities or agencies calculated to conserve human life and its incidence in the nation's industries; and to participate in and aid other activities for the welfare of the industrial worker of the country.[10]

The first service of the council was to issue information bulletins reporting effective safety methods used by members. This has been followed by the publication of *Safe Practices Pamphlets* and *Data Sheets* recording the tested standards for safe industrial operations in many lines. In 1919 the first issue of the *National Safety News,* the council's first periodical, appeared; at present the council publishes six monthly magazines, the *National Safety News, Public Safety, Safety Education, The Industrial Supervisor,* the *Safe Worker* and the *Safe Driver.* Twenty-six sectional news letters are issued monthly for different industrial groups. Five million posters, three million pay inserts, and one and a half million dash cards are issued annually. *Accident Facts,* a 100-page authoritative, statistical summary is issued annually; 25,000 copies are distributed. The council's library and engineering service answer 7,000 inquiries each year. A National Safety Congress is held each year, the *Transactions* of which are published in two volumes, and innumerable smaller safety gatherings are held throughout the year in various parts of the country. Many nation-wide safety contests are held each year.

The council is essentially a service-to-members organization financed almost entirely by membership dues. Industrial or commercial organizations and public utilities may become members of the council on payment of dues according to a scale based on the number of employees. Memberships are also held by numerous libraries, educational institutions, public safety departments, associations, and individuals. The headquarters of the council are in Chicago.

American Society of Safety Engineers.—Another national safety organization, the American Society of Safety Engineers, is affiliated with the National Safety Council and constitutes its engineering section. The American Society of Safety Engineers differs

[10] National Safety Council, *Some Interesting Facts Regarding the Organization and Growth of the National Safety Council.*

from the council in that its membership is confined to individuals professionally engaged in safety work. This organization, through its local chapters, holds monthly meetings for discussion of professional and technical papers. With the council and other safety organizations the American Society of Safety Engineers has participated in the drafting of important national safety codes under the auspices of the American Standards Association.

Other safety organizations.—Regional societies of safety engineers, local councils, the more progressive state industrial commissions, the engineering departments of casualty insurance companies, and branches of the Federal government such as the Bureau of Standards, the Bureau of Mines, and the Department of Labor—particularly its Bureau of Labor Statistics and the Division of Labor Standards—are making important contributions to the industrial-safety movement.

While there can be no such thing as competition in safety work—that is, competition as it is understood in commercial affairs—there is always the possibility of unnecessary duplication. The fact that notwithstanding the many safety organizations in existence there has been no noticeable duplication of effort is one of the highest compliments that can be paid to the executives and directors of these organizations.

The National Society for the Prevention of Blindness.— The position of the National Society for the Prevention of Blindness with respect to the national safety movement was stated in the Preface of this volume. It is appropriate here to mention briefly the nature and functions of the society not only in the industrial field but also in the general affairs of our country. The objects of this society are: (1) to endeavor to ascertain, through study and investigation, any causes, whether direct or indirect, which may result in blindness or impaired vision; (2) to advocate measures which shall lead to the elimination of such causes; (3) to disseminate knowledge concerning all matters pertaining to the care and use of the eyes. The society serves as a bureau of information and an agency of helpfulness to all who are interested in the movement to prevent blindness and to conserve vision.

The following concise statement of the society's activities has been made by Mason H. Bigelow, a member of the Board of Directors:[11]

Particular attention is given to:

1. Advocating adequate prenatal care for every expectant mother, including a blood test and treatment when necessary, as the first steps in the program of preventing blindness from prenatal syphilis.

2. Urging the universal use of prophylactic drops at birth to protect babies' eyes from infection.

3. Demonstrating an approved method of testing the vision of pre-school children in order to discover those who will benefit from early treatment.

4. Coöperating with educational authorities in: (*a*) Conserving the vision of school and college students. (*b*) Establishing sight-saving classes for children whose vision is so defective that they cannot profitably use ordinary school equipment. (*c*) Providing specialized training for teachers of sight-saving classes. (*d*) Helping student-teachers secure better preparation for meeting the eye health problems of school children.

5. Assisting nurses to become increasingly aware of their opportunities for saving sight and aiding in their preparation for this work.

6. Collaborating with those who are striving to reduce eye injuries and eyestrain in industry.

7. Demonstrating the value of specially trained medical social workers in eye hospitals and clinics and helping such workers to secure specialized training.

8. Stimulating and sponsoring research in relation to the causes of blindness and impaired vision.

9. Providing the public with information concerning the care and use of the eyes.

10. Serving as a clearinghouse on all matters pertaining to the prevention of blindness and the conservation of vision.

That part of the program of the National Society for the Prevention of Blindness which has been devoted to the prevention of eye accidents in industries has been carried forward in large part by coöperation with national and local safety organizations and labor departments and other organizations mentioned in the foregoing.

[11] Bigelow, "Legal Status of the National Society for the Prevention of Blindness," *Sight-Saving Review,* VII (Sept., 1937), 210.

Prevention of industrial eye accidents is only one of the many interests of the society. To effect—through its own resources and those of other organizations—reduction in the frequency and the severity of injuries to eyes through accident, disease, or eyestrain in industrial occupations, the Industrial Relations Department of the society has attempted to do three things:

(1) To convince labor and management that eye injuries in industry can be prevented and that it pays to prevent them.

(2) To tell industry generally just how the sight of workers can be conserved—how this is being done in the plants that are doing it most successfully.

(3) To keep prodding employees, employers and safety organizations to give adequate attention to eye protection in industry.

Toward these ends the society has distributed among the industries of America many thousands of copies of its publications concerning the general care and protection of the eyes. The educational work of the society has also been carried forward by numerous talks by its officers and staff, newspaper and magazine articles, radio broadcasts, correspondence with safety engineers and industrial executives, and by direct contact with industrial concerns. In addition the society operates an advisory service and clearinghouse of information on eye hazards in industry through which new developments in protection against or methods of eliminating industrial eye hazards are brought to the attention of industrial concerns, trade and technical associations, safety engineers, representatives of civic and welfare agencies, and others professionally concerned with problems relating to industrial eye hazards. In this work the society has received valuable assistance from its Industrial Advisory Committee, the personnel of which is drawn from leading safety, health, and industrial groups.

The National Society for the Prevention of Blindness is exclusively a public-service organization, supported entirely by membership dues and contributions from public-spirited and philanthropic men and women. It welcomes as members all persons interested in promoting public welfare, particularly in the conservation of the sight of men, women, and children.

There are hundreds of trade associations and other organizations concerned with the prevention of industrial accidents and the promotion of safe practices in industry. It is not possible to discuss them all here. However, a partial list of organizations concerned with Industrial Accident Prevention and Health Promotion is presented in Appendix II.

NEED FOR BETTER SAFETY EDUCATION FACILITIES

In the training and education of workmen, foremen, safety committeemen, safety inspectors, and safety engineers important contributions have been made by several safety and public-welfare agencies, such as those mentioned in the foregoing paragraphs, by a few outstanding corporations, by some state industrial commissions, and by a few casualty insurance companies. Facilities for training the men who are to be in charge of accident prevention in industry still are woefully inadequate, though a start has been made at the New York University Safety Center. Within the individual shop—except in the case of a few of the larger and more progressive corporations—the training and education of workmen and foremen in safe practices are either completely ignored or subordinated to the training and supervision given in methods of speeding up production, lowering costs, and maintaining standards of manufactured products.

Chapter X

ELIMINATING EYE HAZARDS BY ADMINISTRATIVE SUPERVISION

ANALYSIS of the circumstances surrounding 75,000 industrial accidents led H. W. Heinrich, of The Travelers Insurance Company, to the conclusion that 98 percent of all such accidents are preventable and that 88 percent of all industrial accidents could be prevented by proper supervision and administration.[1] It is now nearly ten years since this conclusion was made public and while it has often been the subject of extensive discussion at safety conferences, no one has seriously disputed the statement or attempted to controvert it. One can therefore hardly exaggerate the importance of inspection, supervision, and administration in any effort to conserve life, limb, and sight of industrial workers.

THE MANDATORY GOGGLE RULE

It is not necessary to discuss here the general topic of safety administration, on which abundant literature is readily available elsewhere. One detail of safety administration, however, of vital interest to all those concerned with the prevention of blindness in industry is the "mandatory goggle rule"—that is, a rule requiring the wearing of goggles or other suitable eye-protective equipment at all times and by every person in the plant, including workmen, foremen, supervisors, managers, owners, and visitors. Such a rule—when enforced strictly, though diplomatically, and when

[1] Heinrich, *Industrial Accident Prevention*, p. 45.

supplemented by year-'round safety education, adequate supervision, and mechanical guarding—is, in the opinion of the writer, the best safety device available for protection of the eyes of industrial workers.

There are two schools of thought about the mandatory goggle rule among those professionally concerned with accident prevention. One group takes the position that the mandatory rule is not feasible, because it cannot be enforced, and even if it were enforceable it would greatly increase labor turnover and thereby antagonize production managers not only to it but also to the safety movement as a whole. As against this, those who believe in and advocate the mandatory rule point to the plants in which such a rule has been successfully in force for years, the most notable of which is the Pullman Company.

At the entrance of every Pullman shop or yard, from coast to coast, is an order over the name of the president of the company requiring every person entering the plant to wear goggles. The writer has gone through Pullman plants on various occasions and has always observed complete conformance with this rule and he has yet to hear of a person who was admitted to one of the plants of this company without wearing a pair of goggles. This is in sharp contrast to the situation in most industrial plants, including many which seem otherwise genuinely interested in accident prevention.

In Pullman shops goggles or other eye-protective equipment are worn by steelworkers, of course, but also by carpenters, painters, upholsterers, sewing-machine operators, mattress makers, porters—by all employees, including even clerks and stenographers when they have occasion to step out of the office and through the gate leading to the plant. There is a watchman at the gate who doesn't argue about the goggle rule, but simply blocks the way and points to the president's order when anyone attempts to enter without wearing goggles. If a visitor in the plants of this company has taken off his goggles, it is not unusual for a common laborer or other employee to step up to the visitor, who may be a high supervisory official, and say, "Better put your goggles on, buddy."

To all appearances the Pullman Company has made a fetish of the mandatory goggle rule, but it is a fetish that has paid big dividends in eyes saved among employees and money savings for the company. These facts are gaining wider recognition among industrial safety men generally, and each year additional names are added to the list of companies enforcing a mandatory goggle rule.

A most significant addition to this list took place on February 2, 1939, when the members of the Drop Forging Association unanimously voted the following resolution: "Resolved that all persons in the plant, including visitors, be required to wear safety goggles while on plant property." The Drop Forging Association is composed of 73 plants, which comprise 70 percent of the industry, and employ (early 1941) about 15,000 men.

In the light of the Pullman Company's experience over a period of more than 15 years, the value of a rule requiring the wearing of goggles or other protective equipment by all persons in an industrial plant and at all times can hardly be questioned. The Pullman Company reports it has never been obliged to discharge a person for failure to wear goggles, though some have refused to take employment when they were told of the rule.

This rule should never be announced in a plant unless there is the fullest intention to enforce it and confidence in the ability to do so. There are, of course, many plants where labor difficulties or other special situations make the madatory rule, for the time being, not feasible. It is true also that in small plants the discharge of one particular skilled workman or of some strategically placed employee might so badly retard or disrupt production as to make the mandatory rule inoperable. In these plants there can be no hope of completely eliminating serious eye injuries until the obstacles in the way of an enforceable mandatory goggle rule are removed.

Many plants have what they regard as a mandatory goggle rule—a rule requiring the wearing of goggles or headmasks in certain specified operations under penalty of dismissal or other disciplinary action. Of course, such rules are better than none—

if they are really enforced and if the required protective equipment is always available to the employee. The trouble with such rules, however, is twofold: (1) As soon as certain operations are specified as hazardous and as requiring eye-protective equipment, workmen and foremen naturally assume that all other operations are not hazardous—often with disastrous results; and (2) no one can predict when, where, or how an eye will be injured or destroyed. The files of compensation commissions are full of claims for eye injuries which occurred under the most unexpected circumstances.

The worst form of safety administration is that which leaves to the individual worker the decision as to when he is about to engage in a hazardous operation and leaves to him the choice of wearing protective equipment or working without it. In the same class is that type of safety administration which sets up goggle rules but does not provide goggles and other safety equipment adequate for the hazard. A quarter of a century ago industry accepted the principle that employees are entitled to a safe place in which to work. Later came recognition of the fact that it is good business, as well as common decency, to give employees not only safe working conditions but relative comfort as well—good light, good housekeeping, and general cleanliness.

SUPERVISION

A necessary part of any industrial safety program is a thoroughgoing system of safety supervision or of general plant supervision in which supervision for accident prevention and health protection is considered as important as supervision for any other purpose. Employees can hardly be expected to take seriously attempts to teach them safe practices if little or no effort is made to supervise their work in the interest of safety and to penalize unsafe practices. The best safety education will not be fully effective without adequate safety supervision; this is true, in fact, of any aspect of the safety program including even mechanical guarding.

What is safety supervision?—It is often difficult, if not impossible, to draw a line between education and supervision in

industry; each involves showing, explaining, correcting, telling how and why, checking up, and testing. Supervision, however, includes something more that is vital to any industrial safety program—that is administration of authority. This should be done with a firm hand, but always with justice, reasonableness, and diplomacy.

Safety supervision calls also for: inspection—frequent and thorough—of plant, tools, safety equipment, methods of operation, and all other elements of accident causation; reporting—accurate and detailed—of all accidents resulting in personal injury, and preferably all accidents irrespective of whether injury resulted; investigation—prompt and searching, but open and above board—to ascertain the real cause of each accident and to determine personal responsibility as a preliminary to action designed to minimize the chances of recurrence.

Who can best render safety supervision?—The foregoing is a brief definition of ideal safety supervision. Where any substantial approximation of this definition is attained and where the other major elements of a safety program are competently maintained, accidents and occupational diseases are well under control, workers' eyes are seldom seriously injured, and compensation for loss of vision is a minor factor in production costs.

The decision as to who can best render such safety supervision depends on many factors which differ from plant to plant—on whether there is a safety engineer or safety department, on whether this department has authority to issue and to enforce safety regulations or serves only in an advisory capacity, and on a variety of other factors including that of personalities. Here, as in education, the most important consideration is not *where* the responsibility for safety supervision should lie, but that the responsibility be clear-cut and sincerely designated.

In some plants it has been found most effective to put responsibility for safety inspection, accident reporting and investigation, and every other phase of safety supervision in a safety department, which reports directly to the president, operating vice-president, general manager, or some other high executive who

then issues the necessary safety orders to the engineering department, maintenance department, production department, and other units concerned. In other plants each department head and, through him, each foreman is responsible for safety supervision along with other duties and the safety department or safety engineer, if any, is called in for advice and technical assistance.

Between these two extremes are endless variations, the success or failure of which is determined chiefly by the degree of seriousness with which the management approaches the whole safety problem. This, in turn, determines the caliber of men assigned to safety work and the kind of instruction, inspiration, and material help the foreman gets in carrying out his responsibility for safety supervision.

While safety supervision must come from the top down and must be the concern of every executive and subexecutive if a plant is to be as safe as it can be made, the brunt of the job of safety supervision usually falls on the foreman, for much the same reasons as apply in the case of safety education. Therein lies one of the weaknesses of present-day industrial safety practice.

That few foremen attain the ideal in the quality of their supervision, especially in matters of safety, is not usually a reflection on the foreman. From time immemorial it has been understood that the foreman's first responsibility is "to get the work done," "to turn the stuff out" on time, up to standard quality, and within the scheduled cost. This in itself is usually a substantial responsibility—"a man-sized job," any foreman will say. In addition to this the foreman must get his job done without creating labor problems or setting the spark to labor difficulties which may be long smoldering in the plant, perhaps for reasons entirely beyond his control. As if that were not responsibility enough, the average foreman must assist in the education and the training of his men; he must supervise them for safe practices; in some companies, he must enlist the aid of his men in the company's public relations program or even in its selling program; he must often be the focal point for the plant's welfare activities or—in the absence of a welfare program—must himself assume the role of social worker,

domestic relations counsellor, arbitrator, mediator and sometimes dictator.

The simple fact is that the average foreman has so many and such varied duties that he cannot begin to do justice to all of them. The growing recognition, during the past quarter century, of the foreman's strategic position has made him, in many industrial plants, the catch-all for all sorts of responsibilities and assignments and the channel for passing on to the worker not only the usual plant instructions but also all sorts of doctrines, propaganda, and so-called educational material.

For all these reasons, before the burden of the responsibility for safety supervision is placed upon the foreman in any particular plant, careful consideration should be given to the foreman's other duties and to his capacity for this additional load. Where foremen are too much occupied with other responsibilities to do justice to the additional job of safety supervision and when it is not possible either to augment the number of foremen or to relieve them of other duties so as to give them time for safety supervision, several alternative arrangements can be made.

Supervision through safety committees.—One of the best alternatives is to have a safety committee for each shop, department, or smaller unit depending upon the size, nature, and organization of the company and the frequency of accidents. The members of safety committees should be picked carefully with an eye to willingness and ability to do this sort of work, thoroughness of their knowledge of the entire plant and its operations, and the extent to which they will have the respect and coöperation of their fellow workers. Employees' safety committees, when given responsibility for safety inspection, investigation of accidents, and recommendation of means for anticipating recurrence, have in many plants rendered excellent service in all these fields of safety supervision.

If employees' safety committees are to function properly, it is important that they shall be formally appointed and that their appointment shall be made a matter of public record within the plant, that concrete duties be assigned to them, that they be given

necessary authority to facilitate full inspection and investigation of accidents, that they be permitted to do committee work on company time, and—most important of all—that their findings and recommendations receive careful attention and that frank explanation be made of the reasons for any failure to accept or to carry out their suggestions. Under such circumstances employees' safety committees can relieve the foreman or the safety department of much of the work of safety supervision; and in the process the individual committeemen become more thoroughly educated in matters of safety than is otherwise possible and usually continue to be conscientious observers of safe practices as well as ardent safety advocates among their fellow workers long after they have ceased to be members of the committee.

Under certain circumstances it may not be feasible or desirable to delegate responsibility for safety supervision to employees' committees. In such cases good results may often be obtained by giving this responsibility to one picked worker in each department, perhaps with some such designation as "assistant to the foreman for safety" or "safety inspector" or "safety supervisor." This appointment and the part-time responsibilities that go with it can usually be given with little or no interference with the normal work of the department or of the individual concerned. This, incidentally, provides a fine opportunity for trying out prospective foremanship material without the individual's being aware that he is being tested. In such appointments it is important to guard against the selection of an individual who because of personality or for any other reason may be looked upon with suspicion by his fellow workers, especially when he is making a safety inspection or investigating the circumstances surrounding an accident. A worker who already has the confidence of his fellows and is, officially or unofficially, one of their recognized leaders would be ideal for this post, assuming that he has had fairly wide experience in the various operations of the department concerned, an inquiring mind, and an earnest desire to help make the plant safe as well as to advance his personal position in the company.

Reporting and investigating accidents.—Part of the work to be accomplished by a good supervisory system is the thoroughgoing reporting and recording of accidents, and what is more important, ascertaining the real causes and the persons responsible for the accident. Accidents cannot be prevented unless everything is known about those which have already occurred. The Standard Industrial Injury Reporting System of the National Safety Council[2] is probably the best and simplest method of recording necessary and helpful information about accidents which result in personal injury. This system involves use of five standard forms: (1) a report of industrial accidents; (2) an analysis sheet of industrial accidents; (3) an accident card for each worker; (4) a summary of industrial injuries by departments; and (5) a monthly comparison of injury rates and costs. Through consistent use of these five report forms it is possible to discover where most accidents occur, which employees are most often involved in accidents, what operations and machines are most hazardous, and whether accident costs are increasing or decreasing and why.

A large railway system, which for many years has taken first place in almost every nation-wide railroad safety contest and whose safety record is hardly approached by any other large railroad, credits its enviable record in large part to its method of investigating accidents and penalizing the persons found responsible. Throughout this road and in all its shops a careful inquiry is made into the real cause of each accident. All persons—foremen and other supervisors as well as the injured person and his fellow workers—are questioned; witnesses are required to make written reports or to testify at hearings within the plant; and a thoroughgoing trial is held so that all evidence connected with the accident may be discovered. When every workman, every foreman, and every supervisor knows that every accident will be investigated and that the careless person, irrespective of his position in the plant, will be disciplined and after repeated evidences of carelessness discharged, accidents cease to happen.

State safety supervision.—Supervision by state government de-

[2] National Safety Council, *Industrial Injury Reporting System.*

partments has helped substantially to make the industries of America safe, especially in the case of small plants, but much remains to be done. For example, while 47 of the 48 states now have workmen's compensation laws, Secretary Frances Perkins[3] of the United States Department of Labor, recently emphasized the little-known fact that due to various exemptions and exceptions in many state acts, more than half of all wage earners of the United States are entirely outside the scope of these benefits.

Of special concern to those interested in conservation of the vision of industrial workers is the fact that only 19 states have safety codes specifically mentioning protection of the eyes, only 25 states have industrial lighting codes and only 15 states have mandatory legislation providing a central agency with responsibility for prevention of blindness.

More serious from the point of view of all who are concerned with conserving life and limb as well as sight of the factory workers of America is the fact that 5,000,000 to 6,000,000 industrial workers employed in small plants have no contact with the organized safety movement. These millions of workers and their employers rely chiefly on casualty insurance underwriters and state safety inspectors for information and advice concerning accident and health hazards and means of protection against them. This is seen to be all the more serious when it is known that in all the United States there are fewer than 1,000 state factory inspectors assigned to health and safety work and that many of these have had little training for the work in which they are engaged.

The United States Department of Labor, though having no direct jurisdiction over state departments of labor or over the inspection of industrial plants, is doing much to increase the effectiveness of state factory inspection boards, particularly through training courses for state factory inspectors and assistance to states in the formulation of safety codes.

[3] In an address before the National Safety Congress, Atlantic City, October 16, 1939.

SELF-INSPECTION FOR EYE HAZARDS

With all due respect to insurance inspectors, state factory inspectors, and any other outside inspectors, it may be safely asserted that in industry, as is so often true of individuals, the best inspection is self-inspection—that is, inspection by the plant management itself. Self-inspection can be most effective when it is made for the purpose of discovering the facts rather than for any other purpose.

Such self-inspection should be the first step in any effort—new or renewed—to make a plant safe from accident and occupational disease hazards. In order to assist safety engineers and others who wish to discover eye hazards and the extent to which their plants are equipped to combat these hazards effectively, a list of questions which are suggested by and, in general, follow the order of the foregoing chapters is included in Appendix I: "A Self-Appraisal for Safety Engineers and Other Executives Concerned with Conservation of Vision in Industry."

APPENDICES

Appendix I

A SELF-APPRAISAL FOR EYE SAFETY IN INDUSTRY[1]

THIS SELF-APPRAISAL FORM is prepared especially for the use of safety engineers and other executives concerned with conservation of vision in industry.

A. Are your employees protected against general health hazards?

1. Are there adequate facilities for washing, including hot water and soap, conveniently located and available to all workers?
2. Are individual towels available? Use of roller towels in public places is forbidden in many states as a precaution against the spread of communicable diseases.

B. Has every possible step been taken to eliminate eye hazards through process revision?

1. Is the general housekeeping of the plant such as to reduce to a minimum the possibility that *(a)* workmen may fall or stumble; *(b)* tools or other objects may fall from high places?
2. Are plant layout and machinery arrangement such as to make it unnecessary for any employee to work in a strained position for long periods? Long subjection to abnormal motions or abnormal posture may lead to serious eye disorders as well as to other disabling conditions.
3. Have nontoxic substances been substituted for poisonous ones wherever possible?
4. Is adequate exhaust equipment provided to draw off poisonous fumes and gases which cannot be otherwise eliminated?

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[1] A modification of this appraisal form is in use in a special study undertaken by the National Society for the Prevention of Blindness.

5. Have all hazardous procedures, techniques, and operations been closely examined for possible revision or modification which might reduce or eliminate accident and health hazards?

C. Are your employees properly safeguarded by mechanical means?

1. Are goggles, helmets, and head masks available for each employee exposed to the danger of *(a)* splashing of molten metal or injurious chemicals; *(b)* flying dust or particles of emery, metal, rock, wood or other hard substances; *(c)* falling or thrown tools or other large objects?

2. Do the goggles meet the required strength specified by the *American Standard Safety Code for Protection of Heads, Eyes, and Respiratory Organs?*[2]

3. Are the goggles or other protective devices used in your plant the most comfortable that may be secured?

4. Are goggles fitted to the individual workman?

5. Are emery wheels equipped with glass shields, metal hoods, or other adequate protection?

6. Is some one person charged with responsibility for cleaning and replacing pitted or broken emery-wheel shields?

7. Are emery wheels and other sources of dust or flying particles equipped with exhausts to draw off such particles?

8. Is there adequate provision for keeping tools in good condition: *(a)* through periodic inspection for mushroomed or burred heads, for cracks or other defects; *(b)* through definite responsibility for dressing tools?

9. Are the points of operation of lathes, drills, punch presses, and other high-speed machine tools protected by glass or by wire-mesh guards?

10. Is each worker requiring a head mask, helmet, or goggles provided with such equipment for his exclusive use?

11. Is there provision for sterilization, reconditioning, and adjustment of eye-protective devices returned by one employee before they are issued to another?

12. Are respirators provided for all workers exposed to the dust or fumes of injurious chemicals? Such exposure often leads to impairment of vision as well as other bodily injuries.

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[2] This publication may be obtained from the Superintendent of Documents, Washington, D.C.

13. Where respirators are necessary, is there provision *(a)* for an individual respirator for each worker; *(b)* for sterilization of respirator turned in by one workman and handed to another?

14. Is there adequate provision of proper goggles, masks, and helmets to protect workers from injurious heat and light rays in occupations involving *(a)* acetylene welding; *(b)* electric welding; *(c)* irradiation by ultraviolet light?

D. Do your employees have the proper lighting facilities?

1. Does a foot-candle meter check of illumination in the plant show conformance with the minimum intensities of light indicated in *Recommended Practice of Industrial Lighting?*[3]

2. Is illumination in the plant devoid of *(a)* flickering lights; *(b)* sharply contrasted lights and shadows; *(c)* permanent or intermittent glare?

3. Is the plant arrangement such as to make it unnecessary to expose employees' eyes to: *(a)* glare of the sun; *(b)* unshaded filaments of electric light; *(c)* intense open fires or carbon lights; *(d)* reflection from polished surfaces?

4. Are windows, skylights, and lighting units cleaned often enough to transmit and reflect light as efficiently as possible?

E. Is your plant properly equipped and staffed for first-aid treatment?

1. Is a nurse or doctor quickly available in case of emergencies?

2. If there is no full-time doctor or nurse in your plant, are there any persons especially trained for first-aid treatment?

3. If caustics, acids, or other corrosive substances are used in your plant (see Appendix II), are there readily available showers and eye fountains for washing the eyes in the event of chemical burns?

F. Are proper steps being taken to discover and correct defective vision among your employees?

1. Is good vision a prerequisite to employment in your plant?

2. Are the eyes of all workers examined at the time of employment?

3. Is a report of the findings in such examinations given to the employee or applicant for work?

4. Are employees' eyes reëxamined at stated periods—biennially; annually; or semi-annually?

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[3] This publication may be obtained from the Illuminating Engineering Society, 51 Madison Avenue, New York City.

5. Is there a provision for general physical examination of employees *(a)* at the time of employment; *(b)* at regular recurring intervals; *(c)* when symptoms of disorder appear?

6. Are workmen with seriously defective vision or with disease involving the eyes referred to an oculist?

7. Are goggles with prescription lenses provided for employees with defective vision?

8. Is the visual acuity of each employee taken into account in assigning work?

9. Is there a periodic check of the relation of worker's vision to the character of his job with a chance to change to a less hazardous occupation if necessary?

G. Are you properly educating your employees for safety?

1. Is there a definite and continuous program of safety education which includes *(a)* instruction in the protection of eyes; *(b)* special instruction for new employees; *(c)* provision for discovery and education of accident-prone employees; *(d)* varied instruction for old employees; *(e)* training of foremen for safety education and safety supervision?

2. Are accurate records kept for each plant and department covering *a)* number, nature, and cause—immediate and underlying—of eye injuries; *(b)* frequency and severity rate of such injuries; *(c)* compensation and other costs due to such injuries?

H. Are you properly supervising your plant for safety?

1. Is responsibility fo r safety supervision clearly defined?

2. Is there a mandatory rule requiring the wearing of goggles, masks, or helmets by all persons in the plant at all times, and is this rule conscientiously enforced?

Not all the questions in the appraisal form are pertinent to every industrial plant. However, anyone setting out to make an honest and thorough examination of a work place for the purpose intended by this appraisal form would make a serious mistake if he assumed in advance, or after superficial inquiry, that certain questions might be passed over as "not applicable." Millions of dollars in compensation have been paid by American industries because of eye hazards long assumed nonexistent in their plants—

until a case of blindness or permanent partial loss of vision was definitely traced to the particular operation which had traditionally been considered free from such hazard.

The industrial property for which every question of this self-appraisal can, after thorough examination, honestly be answered in the affirmative is doing everything possible to protect the eyes of its workers and of others who may have occasion to pass through the property. Since nothing is static in industry (or elsewhere), it should not be assumed that the plant for which affirmative answers can be made today will qualify indefinitely, or even next year. The company that wants to know where it stands in the matter of eye protection will accordingly make this self-appraisal periodically—the more frequently the better for its finances and its employees' eyes.

Finally, neither this appraisal form nor the preceding chapters on which it is based tell the whole story of the eye hazards of industry and of what is being done or can be done to eliminate these hazards or to counteract their effect. The National Society for the Prevention of Blindness will welcome further information on this subject, especially from persons whose work gives them opportunity to observe at first hand the conditions which endanger the eyes of industrial workers or who through their professional or occupational experience have direct contact with or interest in the prevention of blindness and the conservation of vision generally.

Appendix II

INDUSTRIAL POISONS WHICH ARE HAZARDOUS TO THE EYES[1]

ACETALDEHYDE (1)

Symptom, condition, or disease:

Irritation of mucous membranes of eyes and respiratory tract; dyspnea and cough; acceleration of heart; profuse night sweats.

Types of workman exposed:

Acetaldehyde workers
Aldehyde pumpmen
Disinfectant-makers
Dye-makers
Explosives workers
Mirror silverers
Photographic workers
Pyroxylin-plastics workers
Resin (synthetic)-makers
Rubber (synthetic)-makers
Varnishers
Varnish-makers
Vinegar workers
Yeast-makers

ACETIC ACID (2)

Symptom, condition, or disease:

Dermatitis; inflammation of the mucous membranes; *conjunctivitis.*

Types of workman exposed:

Bottle cleaners
Bronze cleaners
Chemical workers
Hat-makers
Paraffin separators
Textile printers and dyers
Vinegar-makers

[1] Because in this Appendix eight sources are referred to repeatedly under each topic, the references are listed on p. 271 and numbered to correspond to the numbered items appearing in parentheses throughout this appendix.

ACETONE (1)

Symptom, condition, or disease:

Irritation of skin and *mucous membranes of eyes* and respiratory tract.

Types of workman exposed:

Acetone workers
Acetylene workers
Airplane-dope-makers
Artificial-leather-makers
Cellulose-acetate-makers
Chloroform-makers
Dye-makers
Dyers
Explosives workers
Lacquerers
Lacquer-makers
Methyl-alcohol-makers
Nitrocellulose workers
Oil extractors
Painters
Paint-makers
Paint removers
Paraffin workers
Perfume-makers
Photographic workers
Pyroxylin-plastics workers
Rubber workers
Smokeless-powder-makers
Transparent-wrapping-material workers
Varnishers
Varnish-makers
Wood-alcohol distillers

ACRIDINE (1)

Symptom, condition, or disease:

Irritation of skin and *mucous membranes of eyes* and respiratory tract; violent sneezing.

Types of workman exposed:

Acridine workers
Dye-makers

ACROLEIN (1)

Symptom, condition, or disease:

Irritation of skin and *mucous membranes of eyes* and respiratory tract; bronchial catarrh.

Types of workman exposed:

Acrolein workers
Bone renderers
Candle-makers
Fat renderers
Galvanizers
Glue-makers
Lard-makers
Linoleum-makers
Linseed-oil boilers
Pyroxylin-plastics workers
Refrigerator-makers and repairmen
Soap-makers
Stearic-acid-makers
Tallow refiners
Tinners
Type melters
Varnish-makers

ALKALIES (2)

(Caustic soda, caustic potash lyes, and so forth)

Symptom, condition, or disease:

Caustic burns; dermatitis; eczema; degeneration of the nails; *lesions of the conjunctiva and cornea.*

Types of workman exposed:

Bleachers
Chemical workers
Cotton mercerizers
Dish washers
Metal workers
Rubber workers
Soap- and grease-makers
Wool washers

AMMONIA (1)

Symptom, condition, or disease:

Irritation of respiratory passages; cough and dyspnea; pulmonary edema; bronchitis; *severe irritation of eyes; conjunctivitis;* caustic action on skin.

Types of workman exposed:

Acetylene workers
Ammonia workers
Ammonium-salts-makers
Artificial-ice- makers
Artificial-silk-makers
Boneblack-makers
Bronzers
Calcium-carbide-makers
Coke-oven workers
Color-makers
Cyanide-makers
Dye-makers
Dyers
Explosives workers
Fertilizer-makers
Galvanizers
Gas (illuminating) workers
Gas purifiers
Glue-makers
Lacquer-makers
Mirror-silverers
Nitric-acid-makers
Petroleum refiners
Refrigerating-plant workers
Salt extractors (coke oven byproducts)
Sewer workers
Shellac-makers
Shoe finishers
Soda (Solvay)-makers
Stablemen
Sugar refiners
Tannery workers
Tinners
Varnish-makers

AMYL ACETATE (1)

Symptom, condition, or disease:

Irritation of mucous membranes of eyes, nose, throat, and bronchial tubes; headache and vertigo; fullness of the head; drowsiness; oppression in chest; cough; nausea.

Types of workman exposed:

Airplane-dope-makers
Alcohol-distillery workers
Amyl-acetate workers
Art-glass workers

Artificial leather workers
Artificial-pearl-makers
Artificial-silk-makers
Battery (dry)-makers
Bookbinders
Bronzers
Buffers (rubber)
Calico printers
Camphor-makers
Cutlery-makers
Dyers
Enamelers
Enamel-makers
Explosives workers
Fruit-essence-makers
Furniture polishers
Gilders
Jewelers
Lacquerers
Lacquer-makers
Leather workers
Linoleum-makers
Mottlers (leather)
Nitrocellulose workers
Painters
Paint-makers
Paint removers
Patent-leather-makers
Perfume-makers
Photographic-film-makers
Polishers (wood)
Polish-makers
Pyroxylin-plastics workers
Shellackers
Shellac-makers
Shoe-factory workers
Shoe finishers
Smokeless-powder-makers
Tannery workers
Toy-makers
Varnishers
Varnish-makers
Wirers (incandescent lamps)

AMYL ALCOHOL (1)

Symptom, condition, or disease:

Irritation of eyes and respiratory tract; headache and vertigo; dyspnea and cough.

Types of workman exposed:

Alcohol-distillery workers
Amyl-acetate-makers
Amyl-nitrite-makers
Explosives workers
Fruit-essence-makers
Fusel-oil workers
Lacquerers
Lacquer-makers
Mordanters
Nitrocellulose workers
Painters
Paint-makers
Rubber (synthetic)-makers
Shoe finishers
Smokeless-powder-makers
Varnishers
Varnish-makers

BENZINE (1)

(Naphtha-gasoline)

Symptom, condition, or disease:

Headache and vertigo; nausea and vomiting; irregular respiration; drowsiness; irritation of skin and mucous membranes; "naphtha jag" (a condition resembling mild alcohol intoxication); *visual disturbances;* twitching of the muscles.

Types of workman exposed:

Art-glass workers
Bronzers
Buffers (rubber)
Cast scrubbers (electroplaters)
Cementers (rubber shoes)
Cement mixers (rubber)
Garage workers
Gasoline-engine workers
Gilders
Glue workers
Japan-makers
Japanners
Lacquerers
Lacquer-makers
Linoleum-makers
Lithographers
Metal-polish-makers
Millinery workers
Mixers (rubber)
Mordanters
Chauffeurs
Compositors
Compounders (rubber)
Curriers (tannery)
Decorators (pottery)
Degreasers (fertilizer; leather)
Dippers (rubber)
Painters
Paint-makers
Petroleum refiners
Polishers
Polish-makers
Pressroom workers (rubber)
Printers
Putty-makers
Pyroxylin-plastics workers
Rubber-glove-makers
Rubber-tire builders
Rubber workers
Driers (rubber)
Dry cleaners
Dyers
Electroplaters
Enamelers
Enamel-makers
Feather workers
Furniture polishers
Shade-cloth-makers
Shellackers
Shellac-makers
Shoe-factory workers
Shoe finishers
Tannery workers
Type cleaners
Varnishers
Varnish-makers
Vulcanizers
Waterproof-cloth-makers
Window-shade-makers
Wood workers

BENZOL (BENZENE) AND ITS HOMOLOGUES (TOLUOL AND XYLOL) (1)

Symptom, condition, or disease:

Headache and vertigo; hemorrhages; spots of extravasated blood on the skin; anemia; injury to blood-forming organs, kidneys, liver and nervous system; marked susceptibility to infection; local irritation (bronchitis, *conjunctivitis,* stomatitis, etc.); narcosis (acute poisoning).

Types of workman exposed:

Airplane-dope workers
Alcohol (denatured) workers
Aniline-makers
Artificial-leather-makers
Battery (dry)-makers
Benzol-still men
Blenders (motor fuel)
Brake-lining-makers
Bronzers
Can (sanitary)-makers
Carbolic-acid-makers
Cast scrubbers
Cementers (rubber)
Cement mixers (rubber)
Coal-tar workers
Coke-oven workers

Color-makers
Compounders (rubber)
Decorators (pottery)
Degreasers (fertilizer; leather)
Dippers (rubber)
Driers (rubber)
Dry cleaners
Dye-makers
Electroplaters
Enamelers
Enamel-makers
Engravers
Explosives workers
Extractors (oils and fats)
Feather workers
Gas (illuminating) workers
Gilders
Glue workers
Lacquerers
Lacquer-makers
Linoleum workers
Lithographers
Millinery workers
Mixers (rubber)
Mordanters
Nitrobenzene-makers
Nitrocellulose workers
Oilcloth-makers
Painters
Paint-makers
Paint-remover-makers
Paint removers
Paraffin-makers
Phenol-makers
Photo-engravers
Photographic workers
Picric-acid-makers
Pressroom workers (rubber)
Pyroxylin-plastics workers
Reclaimers (rubber)
Rubber-tire builders
Rubber workers
Shade-cloth-makers
Shellackers
Shellac-makers
Shoe-factory workers
Shoe finishers
Silverers
Smokeless-powder-makers
Soap-makers
Still (coal tar) cleaners
Treaders (rubber)
Trinitrotoluol-makers
Varnishers
Varnish-makers
Vulcanizers
Waterproof-fabric-makers
Welders
Window-shade-makers

BERYLLIUM (4)

Symptom, condition, or disease:

Dermatitis; ulceration; hyperaemia of the nasal mucous membrane; *hyperaemia of the cornea; conjunctivitis; blepharitis; keratitis;* bronchitis.

Types of workman exposed:

Beryllium workers or workers exposed to smoke stack fumes from Beryllium kilns.

BROMINE (1)

Symptom, condition, or disease:

Violent irritation of air passages; bronchitis; *conjunctivitis;* sensation of suffocation; skin eruptions; brownish discoloration of skin and mucous membranes.

Types of workman exposed:

Bromine-salts-makers
Color-makers
Disinfectant workers
Dye-makers
Ethylene-dibromide-makers
Gold extractors
Ink-makers
Photographic-film-makers
Platinum extractors
Tear-gas-makers
Tetraethyl-lead-makers

BUTANONE (3)

(Methylethyl ketone)

Symptom, condition, or disease:

Intolerable irritation of the eyes and nasal passages.

Types of workman exposed:

Artificial-leather-makers
Lacquer- and varnish-makers
Makers of pharmaceutic products
Oils and lubricating media
Paint-remover workers

BUTYL ACETATE, *see* AMYL ACETATE (1)

CALCIUM CYANAMIDE (2)

Symptom, condition, or disease:

Lesions of the skin and mucous membranes; ulcers; laryngitis; bronchitis; *conjunctivitis; ulceration of the cornea;* headache; nausea; vertigo.

Types of workman exposed:

Agricultural workers
Certain chemical workers
Explosives-makers
Manure workers
Metal temperers

CARBON DISULPHIDE (1)

Symptom, condition, or disease:

Headache; vertigo; weakness; psychical effects (hilarity, agitation, irritability, hallucinations, mania); *disturbances* of sensation, *particularly of sight;* peripheral neuritis; digestive disturbances.

Types of workman exposed:

Acetylene workers
Ammonium-salts-makers
Artificial-silk-makers
Asphalt testers
Carbanilide-makers
Carbon-disulphide-makers
Cellulose workers
Cementers (rubber shoes)
Cement mixers (rubber)
Driers (rubber)
Dry cleaners
Electroplaters
Enamelers
Enamel-makers
Explosives workers
Glue workers
Insecticide-makers
Match-factory workers
Oil extractors
Painters
Paint-makers
Paraffin workers
Putty-makers
Reclaimers (rubber)
Smokeless-powder-makers
Sulphur extractors
Tallow refiners
Transparent-wrapping-material workers
Vulcanizers

CARBON MONOXIDE (1)

Symptom, condition, or disease:

Tightness across forehead; *painfulness of the eyeball;* dilatation of cutaneous vessels; headache (frontal and basal); throbbing in temples; weariness; weakness; dizziness; nausea and vomiting; loss of strength and muscular control; increased respiration and pulse; collapse; anemia; polycythemia; presence of carbon monoxide hemoglobin. In some persons poisoning may progress to the stage of collapse without causing any subjective symptoms. Exposure to high concentrations of carbon monoxide for short periods may, through the effect of oxygen deprivation, cause degenerative changes in various tissues of the body. Chronic exposure to low concentrations for long periods of time, according to some investigators, may produce permanent injury.

Types of workman exposed:

Acetylene workers
Ammonia-makers (Haber-Bosch method)
Bakers
Balloon inflaters
Bisque-kiln workers
Blacksmiths
Blasters
Blast-furnace workers
Blockers (felt hats)
Boiler cleaners
Boiler-room workers
Brass founders
Brick burners
Cable splicers
Calico printers
Carbide-makers
Charcoal burners
Chargers (foundries)
Chargers (zinc smelting)
Chauffeurs
Chimney masons
Chimney sweepers
Cleaners (foundries)
Cloth singers
Coal-tar workers
Coke-oven workers
Cooks
Copper smelters
Core-makers
Cupola men (foundries)
Drier workers (foundries)
Drying-room workers (miscellaneous)
Enamelers
Enamel-makers
Engineers (stationary)
Filament-makers and finishers (incandescent lamps)
Firemen (city)
Firemen (stationary)
Flangers (felt hats)
Flue cleaners
Foundry workers
Fumigators
Furnace workers
Garage workers
Gas (illuminating) workers
Gassers (textiles)
Glost-kiln workers
Incandescent-lamp-makers
Ink (printer's)-makers
Ironers
Kiln tenders
Laboratory workers
Laundry workers
Lead smelters
Lime burners
Lime-kiln charges
Linotypers
Mechanics (gas engines)
Mercury smelters
Methane (synthetic)-makers
Methyl alcohol (synthetic)-makers
Miners
Mold breakers (pottery)
Monotypers
Motion-picture-film workers
Neon-light letter-makers
Patient-leather-makers
Phosgene-makers
Plumbers
Pottery (kiln) workers
Pressers
Puddlers (foundries)
Pyroxylin-plastics workers
Refiners (metals)

Repairers (foundries)
Sealers (incandescent lamps)
Sewer workers
Silver melters
Singers (cloth)
Soda-makers (Leblanc)
Solderers
Steeple jacks
Stokers
Teazers (glass)
Telephone linemen (trench work)
Temperers
Top fillers (foundry)
Tubulators (incandescent lamps)
Welders
Wood-alcohol distillers
Wood-charcoal workers
Zinc smelters

CARBON TETRACHLORIDE (1)

Symptom, condition, or disease:

Irritation of nose, *eyes,* and throat; headache; nausea and vomiting; loss of appetite; mental dullness; confusion and excitement; dermatitis.

Types of workman exposed:

Airplane-dope workers
Carbon-tetrachloride workers
Cementers (rubber)
Cement mixers (rubber)
Degreasers (textiles)
Dry cleaners
Electroplaters
Fire-extinguisher-makers
Firemen (city)
Lacquerers
Lacquer-makers
Metal-polish-makers
Paraffin-workers
Perfume-makers
Vulcanizers

CHLORIDE OF LIME (1)

Symptom, condition, or disease:

Irritating cough; inflammation of upper air passage; difficulty in breathing; asthma; bronchitis; *conjunctivitis; lachrymation;* hyperhidrosis; burning eruptions on the skin.

Types of workman exposed:

Acetylene workers
Bleachers
Bleaching-powder-makers
Chloride-of-lime-makers
Chloroform-makers
Disinfectant-makers
Dye-makers
Laundry workers
Mordanters
Tannery workers

CHLORINE (1)

Symptom, condition, or disease:

Irritation of mucous membranes of eyes and respiratory tract; bronchitis; cough; pulmonary edema; dyspnea; pallid countenance and emaciation; gastric disturbances; decayed teeth; irritation of skin; and chloric acne.

Types of workman exposed:

Alkali-salt-makers
Beatermen (paper and pulp)
Bleachers
Bromine-makers
Broom-makers
Calico printers
Chloride-of-lime-makers
Chlorine workers
Color-makers
Detinning workers
Disinfectant-makers
Dye-makers
Extractors (gold and silver)
Ink-makers
Iodine-makers
Laundry workers
Paper-makers
Phosgene-makers
Photographic workers
Rubber-substitute-makers
Shoddy-makers
Soda-makers
Submarine workers
Sulphur-chloride-makers
Tear-gas-makers
Zinc-chloride-makers

CHLORODINITROBENZOL, *see* NITROBENZOL (1)

CHLORONITROBENZOL, *see* NITROBENZOL (1)

CHLOROPRENE (3)

Symptom, condition, or disease:

Irritation of mucous membranes of eyes; nose and gastro-intestinal tract; depression; decreased blood pressure; asphyxia. (Little is known about the toxic effects on man.)

Types of workman exposed:

Makers of synthetic rubber

CHROMIUM COMPOUNDS (1)

Symptom, condition, or disease:

Pitlike phagedenic ulcers, very difficult to heal and very painful, occurring on the skin, most frequently on the hands, and on the mucous membranes; inflammation and perforation of the nasal septum at the cartilaginous portion; eczematous eruptions; *irritations of the conjunctiva* and of the respiratory passages, rarely with inflammation of small areas in the lungs.

Types of workman exposed:

Acetylene workers
Aniline-compound workers
Artificial-flower-makers
Battery (dry)-makers
Bleachers
Blueprint-makers
Calico printers
Candle (colored)-makers
Carbon printers (photography)
Chrome workers
Chromium platers
Color-makers
Compounders (rubber)
Crayon (colored)-makers
Dye-makers

Dyers
Electroplaters
Enamelers
Enamel-makers
Explosives (ammonal and pyroxylin) workers
Frosters (glass and pottery)
Furniture polishers
Glass colorers
Glaze workers (pottery)
Ink-makers
Linoleum workers
Lithographers
Match-factory workers
Mixers (rubber)
Mordanters
Painters
Paint-makers
Paper hangers
Pencil (colored) makers
Photo-engravers
Photographic workers
Photogravure workers
Rubber workers
Steel (chrome)-makers
Tannery (chrome) workers
Vulcanizers
Wall-paper printers
Waterproofers (paper and textile)
Wax-ornament workers
Wood polishers
Wood stainers

CRESOL (CRESYLIC ACID) (1)

Symptom, condition, or disease:

Toxic effects resemble those of phenol, but are less severe. The chief symptoms are irritation and erosion of skin and mucous membranes and nephritis.

Types of workman exposed:

Artificial-resin-makers
Coal-tar workers
Cresol-soap-makers
Cresylic-acid-makers
Disinfectant-makers
Dye-makers
Explosives workers
Fumigators
Perfume (synthetic)-makers
Resin (synthetic)-makers
Rubber (artificial) workers
Tar-distillery workers

DIMETHYL SULPHATE (1)

Symptom, condition, or disease:

Strongly corrosive effect on the skin and mucous membranes; hoarseness; *lachrymation; conjunctivitis;* bronchitis; pulmonary edema with hemorrhages; *photophobia; total or partial color blindness.*

Types of workman exposed:

Dimethyl-sulphate-makers
Dye-makers
Perfume-makers

DINITROBENZOL, *see* NITROBENZOL (1)

DINITROPHENOL (2)

Symptom, condition, or disease:

Gastro-intestinal disorders; vertigo; pulmonary constriction; *cataract.*

Types of workman exposed:

Dinitrophenol workers
Explosives-makers
Sulphur-black-dye workers
Timber-preservative workers

DIOXAN (DIETHYLENE DIOXIDE) (1)

Symptom, condition, or disease:

This compound may be used in the manufacture of a number of chemicals and is a solvent for nitrocellulose, fats, oils, wax, guns, and so forth. According to the United States Bureau of Mines, men exposed to air containing 0.16 percent of dioxan vapor by volume immediately noted *irritation of the eyes,* nose, and throat. It is stated that "as in the case of practically all comparatively nontoxic volatile liquids, dioxan presents a hazard to life under conditions of exposure to air confined over the liquid in tanks, vats, and similar places where high concentrations would accumulate."

ETHYL BENZENE (1)

Symptom, condition, or disease:

This compound is used as an "antiknock," as a lacquer diluent, general solvent, and so forth. According to the United States Bureau of Mines, animal experimentation shows *irritation of eyes,* and nose; apparent vertigo; static and motor ataxia; apparent unconsciousness; tremor of extremities; rapid jerky respiration; then shallow respiration; and finally slow, gasping respiration, followed by death. All these symptoms and death resulted from 1 percent exposure in from 2 to 3 hours.

ETHYLENE DIBROMIDE (1)

Symptom, condition, or disease:

Irritation of eyes and respiratory tract; vomiting; pallor; weakness; vertigo.

Types of workman exposed:

Ethylene-dibromide-makers

ETHYLENE DICHLORIDE (1)

Symptom, condition, or disease:

This compound is used as a solvent, particularly in the extraction of oil and fats. According to the United States Bureau of Mines animal experimentation shows *irritation of eyes* and nose; vertigo;

static and motor ataxia; retching movements; semiconsciousness and unconsciousness accompanied by uncoördinated movements of the extremities; and death if exposure is continued. Exposure to 6 percent vapors caused all these symptoms, except death, to occur in less than 10 minutes, and death in about 30 minutes.

ETHYLENE OXIDE (1)

Symptom, condition, or disease:

This compond is principally used as an intermediate in the synthesis of other compounds as ethel, methyl, and butyl cellosolve, and as a fumigant. According to the United States Bureau of Mines, animal experimentation shows *irritation of the eyes* and nose; blood-tinged, frothy, serous exudate from nostrils; unsteadiness on feet and staggering inability to stand; respiratory disturbances; dyspnea and gasping; and death. Most of these symptoms occurred with exposure to concentrations of 8.5 to 0.3 percent by volume.

FORMALDEHYDE (1)

Symptom, condition, or disease:

Irritation of mucous membranes; *conjunctivitis;* bronchitis; dyspnea; severe dermatitis; destruction of finger nails. Systematic effects, including degeneration of the liver, have been reported.

Types of workman exposed:

Artificial-amber-makers
Artificial-silk-makers
Bakelite-makers
Brewery workers
Broom-makers
Brush-makers
Calico printers
Disinfectant workers
Dye-makers
Embalmers
Explosives workers
Formaldehyde workers
Germicide-makers
Glass etchers
Ink-makers
Insecticide-makers
Mirror silverers
Paper-makers
Photographic workers
Preservative-makers and handlers
Resin (synthetic)-makers
Recoverers (gold and silver)
Rubber workers
Soap-makers
Straw-hat-makers
Tannery workers
Textile printers
Waterproofers (paper)

FORMIC ACID, *see also* FORMALDEHYDE (1)

Symptom, condition, or disease:

Dermatitis (blisters, ulcerations, necrosis); *irritation of mucous membranes of eyes,* nose, and throat.

Types of workman exposed:

Alcohol fermenters
Cellulose-formate-makers
Dye-makers
Electroplaters
Formic-acid workers
Lacquerers
Lacquer-makers
Mirror silverers
Mordanters
Perfume-makers
Rubber workers
Soap-makers
Tannery workers
Varnishers
Varnish-makers

GASOLINE, *see* BENZINE (1)

HEXANONE (3)
(Methyl-Butyl ketone)

Symptom, condition, or disease:

Intolerable irritation of the eyes and nasal passages.

Types of workman exposed:

Lacquer- and varnish-makers
Nitro-cellulose workers
Paint-remover workers

HYDROCHLORIC ACID (1)

Symptom, condition, or disease:

Caustic and irritating action on skin and mucous membranes; *conjunctivitis;* coryza; pharyngeal and bronchial catarrh; dental caries; pulmonary hemorrhages.

Types of workman exposed:

Acetic-acid-makers
Acid dippers
Acid finishers (glass)
Acid mixers
Acid recoverers
Acid transporters
Alkali-salt-makers
Ammonium-salts-makers
Aniline-makers
Artificial-silk-makers
Battery (dry)-makers
Bleachers
Bronzers
Calico printers
Camphor-makers
Carbonizers (shoddy)
Cartridge dippers
Cement-makers
Chlorine-compound-makers
Chlorine-makers
Dye-makers
Dyers
Electroplaters
Enamel-makers
Engravers
Etchers
Fertilizer-makers
Galvanizers
Glass finishers
Glass mixers
Glaze mixers (pottery)
Glazers (pottery)
Glue-makers
Hydrochloric-acid-makers
Ink-makers
Jewelers
Leather workers
Lithographers
Metal cleaners
Metal refiners
Paint-makers
Paper-mill workers
Petroleum refiners
Phosphate extractors
Photographic workers
Picklers (metals)
Pottery workers
Reclaimers (rubber)
Shoddy workers
Soap-makers
Solderers
Sugar refiners
Sulphur-chloride-makers
Tannery workers
Tinners
Transparent-wrapping-material workers
Vignetters
Wire-makers
Zinc-chloride-makers

HYDROFLUORIC ACID (1)

Symptom, condition, or disease:

Intense irritation of eyelids and conjunctiva; coryza, bronchial catarrh with spasmodic cough; ulceration of the nostrils, gums, and oral mucous membranes; painful ulcers of the cuticle; erosion and formation of vesicles; suppuration under the finger nails.

Types of workman exposed:

Aluminum extractors
Antimony-fluoride extractors
Art-glass workers
Bleachers
Brewers
Dyers
Etchers
Fertilizer-makers
Glass finishers
Gold refiners
Hydrofluoric-acid-makers
Phosphorus extractors
Silicate extractors

LEAD AND ITS COMPOUNDS (1)

Symptom, condition, or disease:

Ashen pallor; metallic taste; gastrointestinal disturbances; constipation; abdominal pains; lead line on gums; asthenia; lassitude; headache; backache; pain about joints; weakness of grip; tremors of fingers and tongue; lead paralysis, especially of muscles used most; stippling of red blood cells; *ocular disturbances;* mental symptoms (lead encephalopathy).

Types of workman exposed:

Acid finishers (glass)
Amber workers
Art-glass workers
Artificial-flower-makers
Babbitters
Battery (dry)-makers
Bench molders (foundry)
Blacksmiths
Blooders (tannery)
Bookbinders
Bottle-cap-makers
Brass founders
Brass polishers
Braziers
Brick burners
Brick-makers
Bronzers
Browners (gun barrels)
Brush-makers
Buffers (rubber)
Burners (enameling)
Cable-makers
Cable splicers
Calico printers
Canners
Cartridge-makers
Chargers (zinc smelting)
Chippers
Colorers (white) of shoes
Color-makers
Compositors
Compounders (rubber)
Concentrating-mill workers (lead and zinc)
Copper refiners
Cut-glass workers
Cutlery-makers
Cutters (oxyacetylene and other gases)
Decorators (pottery)
Dental workers
Diamond polishers
Dye-makers
Dyers
Electroplaters
Electrotypers
Embroidery workers
Emery-wheel-makers
Enamelers
Enamel-makers
Farmers
File cutters
Filers

Filling-station workers
Floor molders (foundry)
Galvanizers
Garage workers
Gardeners
Gasoline blenders
Glass finishers
Glass mixers
Glass polishers
Glaze dippers (pottery)
Glaze mixers (pottery)
Glost-kiln workers
Gold refiners
Grinders (metals)
Grinders (rubber)
Heater boys (riveters)
Imitation-pearl-makers
Incandescent-lamp-makers
Insecticide-makers
Japan-makers
Japanners
Jewelers
Junk-metal refiners
Labelers (paint cans)
Lacquerers
Lacquer-makers
Lead burners
Lead-foil-makers
Lead miners
Lead-pipe-makers
Lead-salts-makers
Lead smelters
Linoleum-makers
Linotypers
Linseed-oil boilers
Lithographers
Lithtransfer workers
Match-factory workers
Mirror silverers
Mixers (rubber)
Monotypers
Musical-instrument-makers
Nitric-acid workers
Nitroglycerin-makers
Painters
Paint-makers
Paint removers
Paper hangers
Patent-leather-makers
Petroleum refiners
Photograph retouchers
Pipe fitters
Plumbers
Polishers
Pottery workers
Printers
Putty-makers
Putty polishers (glass)
Pyroxylin-plastics workers
Reclaimers (rubber)
Red-lead workers
Refiners (metals)
Riveters
Roofers
Rubber workers
Sagger-makers
Sandpaperers (enameling and painting auto bodies, etc.)
Screen workers (lead and zinc smelting)
Sheet-metal workers
Shellackers
Shellac-makers
Shot-makers
Slip-makers (pottery)
Slushers (porcelain enameling)
Solderers
Solder-makers
Stainers (shoes)
Steel engravers
Stereotypers
Storage-battery-makers
Sulphuric-acid workers
Table turners (enameling)
Tannery workers
Temperers
Tetraethyl-lead-makers
Tile-makers
Tin-foil-makers
Tinners
Toy-makers
Transfer workers (pottery)
Tree sprayers
Type founders
Typesetters
Varnishers
Varnish-makers
Wall-paper printers
Welders
White-lead workers
Wood stainers
Zinc miners
Zinc smelters

LIME (2)

(Calcium Oxide)

Symptom, condition, or disease:

Skin lesions; *conjunctival and corneal lesions;* trichiasis; syntropion; nasal ulceration; pneumonia.

Types of workman exposed:

Agricultural workers
Calcium-carbide-makers
Cement-makers
Cement workers
Dye workers
Gas purifiers
Kiln chargers
Lime stokers
Match-makers
Metal polishers
Paperhangers
Plasterers
Rough casters
Slakers
Soap-makers
Tannery workers
Textile dyers
Textile printers
Whitewashers

METHANOL (1)
(Methyl alcohol)

Symptom, condition, or disease:

Headache; nausea and vomiting; vertigo; irritation of mucous membranes; severe colic; convulsions; paralysis; chilliness and cold sweats; cyanosis; loss of reflexes and of sensation; irregular and intermittent heart action; rapid breathing followed by retardation; rapid and marked drop in temperature; *affections of sight, including amblyopia, optic neuritis, conjunctivitis, mydriasis, nystagmus, visual hallucinations, blindness.*

Types of workman exposed:

Aldehyde pumpmen
Anilene-dye-makers
Antifreeze-makers
Art-glass workers
Artificial-flower-makers
Artificial-silk-makers
Automobile painters
Bookbinders
Bronzers
Brush-makers
Calico printers
Cementers (rubber shoes)
Dimethyl-sulphate-makers
Driers (felt hats)
Dry cleaners
Dye-makers
Explosive workers
Feather workers
Felt-hat-makers
Filament-makers (incandescent lamps)
Fitters (shoes)
Furniture polishers
Gilders
Hardeners (felt hats)
Incandescent-lamp-makers
Ink-makers
Japan-makers
Japanners
Lacquerers
Lacquer-makers
Lasters (shoes)
Linoleum-makers
Methyl-alcohol workers
Methyl-compound-makers
Millinery workers
Mottlers (leather)
Painters
Paint-makers
Patent-leather-makers
Perfume-makers
Photo-engravers
Photographers
Polishers (wood)
Polish-makers
Pyroxylin-plastics workers
Rubber workers
Shellackers
Shellac-makers
Shoe-factory operatives
Shoe finishers
Soap-makers
Stiffeners (felt hats)
Stitchers (shoes)
Type cleaners
Upholsterers
Varnishers
Varnish-makers
Vulcanizers
Wood-alcohol distillers
Woodworkers

METHYL BROMIDE (1)

Symptom, condition, or disease, *see* note under Methyl Chloride.

Types of workman exposed:

Methyl-bromide-makers	Refrigerator (mechanical)-makers and repair men

METHYL CHLORIDE (1)

Symptom, condition, or disease:

Progressive drowsiness; vertigo; nausea; staggering gait; mental confusion; weakness; *visual disturbances;* tremors; presence of formates and acetone in urine; insomnia. Experiments conducted by the United States Bureau of Mines on guinea pigs showed that air containing methyl chloride, methyl bromide, ethyl bromide, and ethyl chloride produced similar symptoms, including excitement; loss of equilibrium; inability to walk; rapid pulse; convulsive rapid respiration with râles; frothy (often blood-tinged) exudate from nostrils. The signs of lung irritation were not as pronounced for exposure to ethyl chloride as for the other compounds.

Types of workman exposed:

Chloroform-makers	Dye-makers	Refrigerator (mechanical)-makers and repair men
Color-makers	Methyl-chloride-makers	

METOL (7)

(Monomethyl Para-Amidometacresol Sulphate)

Symptom, condition, or disease:

Dermatitis, *inflammation of the eyelids.*

Types of workman exposed:

Photographers

NAPHTHALINE (2)

Symptom, condition, or disease:

Vesicular spots on the cornea, developing into ulceration; chorioretinitis; conjunctivitis; cataract; dermatitis; irritation of respiratory system; anemia.

Types of workman exposed:

Asphalt workers	Gas factory workers
Celluloid workers	Naphthaline workers
Coloring-agent workers	Skin sorters

NITROBENZOL AND OTHER NITRO COMPOUNDS OF BENZOL AND ITS HOMOLOGUES (1)

Symptom, condition, or disease:

Cyanotic face and lips; nausea and vomiting; odor of bitter almonds in breath; irritation of skin; icteric skin; *visual disturbances;* anemia; dark-brown blood; methemoglobin formation; presence of hematoporphyrin; albumin and sometimes free poison in urine; tremors; muscular twitching and other manifestations of nerve injury.

Types of workman exposed:

Aniline-makers
Dye-makers
Explosives workers
Floor-polish-makers
Ink-makers
Nitrobenzol workers
Perfume-makers
Shoe dyers
Smokeless-powder-makers
Soap-makers
Trinitrotoluol-makers

NITROGLYCERINE (7)

Symptom, condition, or disease:

Sudden blindness in one eye or both eyes, followed by headache, accompanied by nausea; *later restoration of vision* accompanied by flushed face and rapid heart.

Types of workman exposed:

Dynamite- and nitroglycerine-makers and handlers (Nitroglycerine workers usually develop an immunity which can, however, be destroyed by a short absence from work or by very hot weather).

NITRONAPHTHALENE *see* NITROBENZOL (1)

NITROUS FUMES (2)

Symptom, condition, or disease:

Inflammation of the larynx; nausea; violent colic; diarrhea; cyanosis of the lips; *irregular pupil; paralysis of the eye muscles;* inflammation of the mucous membranes; *conjunctivitis;* discoloration of the teeth.

Types of workman exposed:

Aniline workers
Artificial-leather-makers
Artificial-silk workers
Celluloid-makers
Chemical workers
Electroplaters
Enamelers
Engravers
Glass-bead-makers
Glue-makers
Metal cleaners and refiners
Miners (in mines and quarries where explosives are used)
Photogravure workers
Synthetic-ammonia-makers

OZONE (1)

Symptom, condition, or disease:

Irritation of eyes and respiratory tract.

Types of workman exposed:

Bleachers	Electrical workers	Laundry workers

PARAFFIN (2)

Symptom, condition, or disease:

Dermatitis; headache; somnolence; *irritation of conjunctiva;* bronchitis; diarrhea.

Types of workman exposed:

Furniture polishers	Match-makers	Water-proofers
Lubricators	Paraffin workers	Wax- and cosmetic-makers

PETROLEUM (2)

Symptom, condition, or disease:

Inflammation of the skin; acne; suppurating ulcers; numbness; irritation of the Schneiderian membrane; headache; affections of the respiratory organs; *irritation of the conjunctiva; nystagmus; disorders of the pupil with mydriasis; paralysis of the eye muscles.*

Types of workman exposed:

Browners (gun barrels)	Lacquer-makers	Paraffin workers
Dry cleaners	Lampblack-makers	Petroleum refiners
Feather workers	Millinery workers	Rubber-goods workers
Furnisher polishers	Mineral oil workers	Solvent-makers
Ink-makers	Oil-flotation-plant workers	Temperers
	Oil-well workers	

PITCH (2)

Symptom, condition, or disease:

Acne; *conjunctivitis; hyperpigmentation of the conjunctiva;* dermatitis.

Types of workman exposed:

Artificial-asphalt-makers	Pasteboard-makers	Pitch-workers
Fuel-makers	Painters	Varnish workers

POISONOUS WOODS (2)

Poisonous woods include: scented wood; iron wood; yellow wood; courbaril; lignum nephriticum; bone wood; purple or violet wood; red or Brazil wood; satinwood; teak wood; greenwood; cumaru wood or tonka; cocus wood; black ebony wood; West Indian mahogany; West African boxwood; Maracaibo boxwood; magenta rosewood; tagayasan; Australian mohwah wood; cocoloba; sabicu; and other woods (see International Labour Office, *Occupation and Health*,—II, 681).

Symptom, condition, or disease:

Dermatitis; inflammation of mucous membranes; *conjunctivitis; irido-cyclitis; keratitis;* nausea; chills and fever; respiratory disorders. The toxicity of poisonous woods varies in degree and in symptoms. The problems of any one wood should be studied separately.

Types of workman exposed:

Box-makers
Cabinet-makers
Dye-makers
Japanese-lacquer-makers
Naval woodworkers
Perfume-makers
Railroad car woodworkers
Shuttle-makers

PYRIDINE (1)

Symptom, condition, or disease:

Irritation of respiratory tract and *of eyes;* cough; dermatitis. symptoms following ingestion include headache; vertigo; trembling of extremities.

Types of workman exposed:

Denatured-alcohol workers
Gilders
Lacquerers
Lacquer-makers
Pencil-makers
Pyridine-makers

QUININE (6)

Symptom, condition, or disease:

Dermatitis; eczema; *diminution of vision; temporary blindness.*

Types of workman exposed:

Hairdressers
Pharmaceutical chemists and druggists
Quinine extractors
Quinine-tablet-makers
Quinquina-bark removers

SULPHUR DIOXIDE (1)

Symptom, condition, or disease:

Irritation and inflammation of mucous membranes of eyes and respiratory tract; spasmodic cough; bronchial catarrh; digestive disturbances; blood-tinged mucous; inflammation of lungs.

Types of workman exposed:

Alkali-salt-makers
Artificial-ice-makers
Blast-furnace workers
Bleachers
Bone extractors
Brass founders
Brick-makers
Broom-makers
Carbolic-acid-makers
Cellulose workers
Ceramic workers
Chambermen (sulphuric acid)
Chargers (zinc smelting)
Coke-oven workers
Copper smelters
Digester-house workers (paper and pulp)
Disinfectant workers
Dye-makers
Feather workers
Fertilizer-makers
Flue cleaners
Fruit preservers
Fumigators
Galvanizers
Gelatine-makers
Glass-makers
Glue-makers
Lead smelters
Mercury smelters
Oil-flotation-plant workers
Paper-mill workers
Petroleum refiners
Pottery workers
Pyrites burners
Refiners (metals)
Refrigerator (mechanical)-makers and repairmen
Smelters
Storage-battery chargers
Sugar refiners
Sulphite cooks
Sulphur burners
Sulphurers (malt and hops)
Sulphuric-acid workers
Tannery workers
Towermen (sulphuric acid)
Ultramarine-blue-makers
Vulcanizers (rubber)
Zinc smelters

SULPHURETTED HYDROGEN (1)

Symptom, condition, or disease:

Irritation of mucous membranes of eyes and respiratory tract; *conjunctivitis;* bronchitis; rhinitis; pharyngitis and laryngitis; pulmonary edema; headache and vertigo; hyperpnea; gastro-intestinal disturbances; brachycardia.

Types of workman exposed:

Alkali-salt-makers
Artificial-silk-makers
Barium-carbonate-makers
Blast-furnace workers
Bottlers (mineral water)
Bronzers
Cable splicers
Caisson workers
Carbon-disulphide-makers
Cellulose extractors
Coke-oven workers
Cyanogen-makers
Digester-house workers (paper and pulp)
Dye-makers
Fat renderers
Fertilizer-makers
Flax-rettery workers
Gas (illuminating) workers
Gas purifiers
Glue workers
Gypsum workers

Hydrochloric-acid-makers
Hydrogen-sulphide workers
Match-factory workers
Miners
Oil-flotation-plant workers
Oil-well workers
Petroleum refiners
Phosphorus-compound-makers
Pulp-mill workers
Pyrites burners
Pyroxylin-plastics workers
Sewer workers
Soap-makers
Soda (Leblanc)-makers
Sodium-sulphide-makers
Starch-makers
Sugar refiners
Sulphides-makers
Sulphur-chloride-makers
Sulphuric-acid-makers
Sulphur miners
Tannery workers
Transparent-wrapping-material workers
Tunnel workers
Vulcanizers

SULPHURIC ACID (1)

Symptom, condition, or disease:

Corrosive action on the skin; *severe inflammation of the mucous membranes of the eyes* and respiratory tract; injury to the teeth through softening of the dentine; chronic catarrh.

Types of workman exposed:

Acid dippers
Acid finishers (glass)
Acid mixers
Acid recoverers
Acid transporters
Alum workers
Ammonium-salts-makers
Ammonium-sulphate-makers
Artificial-leather-makers
Artificial-silk-makers
Benzene purifiers
Beta-still operators (beta naphthol)
Burnishers (iron and steel)
Calico printers
Carbolic-acid-makers
Carbonizers (shoddy)
Cartridge dippers
Chambermen (sulphuric acid)
Color-makers
Dimethyl-sulphate-makers
Dye-makers
Electroplaters
Engravers
Etchers
Ether-makers
Explosives workers
Fat purifiers
Felt-hat-makers
Fertilizer-makers
Galvanizers
Glass finishers
Glue-makers
Guncotton dippers
Hydrochloric-acid-makers
Hydrocyanic-acid-makers
Jewelers
Linoleum-makers
Lithographers
Mercerizers
Nitrators
Nitric-acid-makers
Nitrobenzene-makers
Nitrocellulose-makers
Nitroglycerine-makers
Oil purifiers
Paper-makers
Patent-leather-makers
Perfume-makers
Petroleum refiners
Phenol-makers
Phosphoric-acid-makers
Phosphorus-evaporating-machine workers
Photographic workers
Picklers (metals)
Picric-acid-makers
Pyroxylin-plastics workers
Rayon-makers
Reclaimers (rubber)
Refiners (metals)
Salt extractors (coke-oven byproducts)
Scourers (metals)
Shoddy workers
Soap-makers

Soda (Leblanc)-makers
Storage-battery workers
Sugar refiners
Sulphates-makers
Sulphuric-acid-makers
Tallow refiners
Tannery workers
Temperers
Towermen (sulphuric acid)
Transparent-wrapping-material workers
Wax refiners
Wire drawers
Yeast-makers

TAR (1)

Symptom, condition, or disease:

Tar itch; acne; eczema or psoriasis; *ulcers of the* skin and *cornea;* epitheliomatous cancer; loss of appetite; nausea; diarrhea; headache; vertigo; irritation of the respiratory tract; *conjunctivitis;* albuminuria; edema; ischuria.

Types of workman exposed:

Artificial-stone-makers
Asphalt workers
Battery (dry)-makers
Briquet-makers
Brush-makers
Chimney sweepers
Coal-tar workers
Coke-oven workers
Cord-makers
Creosoting-plant workers
Electrode-makers
Flue cleaners
Gas (illuminating) workers
Insulators
Painters (tar)
Paint-makers
Paraffin workers
Pavers
Petroleum refiners
Pitch workers
Roofers
Roofing-paper workers
Still (coal tar) cleaners
Tar workers
Wood preservers

TEA (5)

Symptom, condition, or disease:

Temporary blindness.

Types of workman exposed:

Tea tasters

THALLIUM (1)

Symptom, condition, or disease:

Reddish discoloration and falling out of the hair; pains in the limbs; *severe eye affections;* inflammation of the kidneys.

Types of workman exposed:

Artificial-gem-makers
Color-makers
Depilatory-makers
Disinfectant-makers
Dye-makers
Filament-makers (incandescent lamps)
Glass workers
Thallium workers
Thermometer-makers

TOBACCO (5)

Symptom, condition, or disease:

Cerebral congestion, anaemia, gastritis, enteritis, *conjunctivitis, amblyopia, blindness (in connection with alcoholism).*

Types of workman exposed:

Cigar-makers	Tobacco-farm workers	Tobacco workers (all kinds)

TURPENTINE (1)

Symptom, condition, or disease:

Irritation of mucous membranes of eyes, nose, and upper air passages; cough; bronchial inflammation; salivation; headache and vertigo; irritation of kidneys and bladder; strangury; odor of violets in urine; severe irritation of skin; hardening of the epidermis.

Types of workman exposed:

Art-glass workers	Japan-makers	Printers
Cable splicers	Japanners	Rubber workers
Calico printers	Lacquerers	Sealing-wax-makers
Camphor-makers	Lacquer-makers	Shellackers
Cementers (rubber)	Linoleum-makers	Shellac-makers
Decorators (pottery)	Lithographers	Transfer workers (pottery)
Dry cleaners	Millinery workers	Turpentine extractors
Dye-makers	Painters	Varnishers
Enamelers	Paint-makers	Varnish-makers
Enamel-makers	Patent-leather-makers	
Feather workers	Polishers	
Furniture polishers	Polish-makers	

MAKING AN INSPECTION FOR HEALTH HAZARDS[2]

1. Determine the raw materials (for our purpose all materials brought into a plant for processing or for use in the process are raw materials). In some cases materials such as solvents, binders, dye bases, rubber accelerators, and so forth are known by trade names only. In such cases it may be necessary to press the inquiry to the firm manufacturing them.

2. Wide knowledge of the way in which each toxic substance may gain access to the system is essential. For instance, lead by inhalation, not, except in most exceptional circumstances, through the skin; chromium chiefly as an acid mist; anilene chiefly through the skin.

[2] Report of Proceedings of a Training Course for State Factory Inspectors, Bulletin No. 6, Division of Labor Standards, U. S. Department of Labor, p. 28.

3. With a knowledge of exactly what toxic materials are used, find out the conditions under which each is used and the extent of the exposures entailed. When dusts, fumes, or gases are the sources of hazard it is important to remember that the chief factors are concentration and length of exposure.

4. Exposures that are not clearly nonhazardous should be carefully studied. Dust counts should be taken and analyses made to determine percentages of the toxic substance present in relation to known limits. The presence of such substances as mercury, lead, or arsenic on walls, floors, and so forth should be investigated.

5. Possible results if processes are not kept under control (such as overheating, tank or line breaks, and so forth) should be studied.

6. The generation or release of hazardous fumes that may result from fire should be considered.

7. Hazards arising from the handling and the storage of dangerous supplies such as acids, caustics, solvents, gases under pressure, celluloid, and nitrocellulose, powerful oxidizing agents, and so forth should receive careful attention.

8. Equipment for emergency and reserve purposes should be very carefully determined. Its location, maintenance, and training in its use are obviously of vital importance.

9. The actual record of the plant should be studied as far as it is available and if records are not already kept, arrangements should be made to keep them. For complete information, all absences and turnover should be investigated, though in practice it is difficult to secure such a check-up on the workers in occupations which do not have an admittedly high hazard.

The foregoing fundamentals are to be regarded as suggestive rather than complete.

Preventive hygiene when toxic substances are used in industry consists mainly of complete cleanliness in all parts of plants where the poisons are used or stored. Floors, walls, machinery, clothing, and skin of exposed workmen should be thoroughly cleaned as often as practicable. When the toxic substance is in the form of fumes or vapors, adequate ventilating systems should be installed, and all pipes, tanks, and receptacles of any kind should be absolutely leak-proof. Close-fitting, air-tight goggles are advisable. When the toxic substance is a liquid, floors should be made of cement or some other inert substance and should be so constructed that the liquid, escaping from a receptacle, will not present danger to nearby workmen.

Certain employees are abnormally susceptible to certain poisons; such workers should be transferred to other employment. Men and

women with respiratory diseases or skin diseases or who use alcohol to excess or who are generally allergic are usually predisposed to the harmful effects of many poisons.

The toxic qualities of some industrial poisons can be counteracted by specific measures. For example, nitrous fumes can be neutralized by liberating an alkaline gas such as ammonia. Silica gel has also been used to absorb nitrous fumes. In the case of calcium cyanamide, which is hazardous mainly in dust form, the addition of 10 to 20 percent mineral oil after grinding diminishes the dust. Box respirators in which the filtering material is activated charcoal have been found satisfactory for reducing the harmful effects of formaldehyde.

REFERENCES CITED IN APPENDIX II

(1) Dublin and Vane, *Occupational Hazards and Diagnostic Signs.*

(2) International Labour Office, *Occupation and Health,* Vols. 1–2.

(3) International Labour Office, *Occupation and Health,* Supplement, 1939.

(4) International Labour Office, *Occupation and Health,* Supplement, 1938.

(5) National Safety Council, *Industrial Eye Hazards.*

(6) Steinbugler, "Eye Conditions Prevalent in Early Adult Life," *Sight-Saving Review,* VI (No. 3), 178.

(7) Eilmann, *Medicolegal and Industrial Toxicology, Criminal Investigation, Occupational Diseases.*

(8) United States, Department of Labor, *Report of Proceedings of a Training Course for State Factory Inspectors.*

Appendix III

RECOMMENDED MINIMUM STANDARDS OF ILLUMINATION FOR INDUSTRIAL INTERIORS[1]

These foot-candle values represent order of magnitude rather than exact levels of illumination. Capital letters refer to the lighting recommendations on page 279; the numerals indicate the minimum operating foot-candles, measured on the work.

Aisles, stairways, passageways, 5

Assembly
- Rough, 10
- Medium, 20
- Fine, B
- Extra fine, A

Automobile manufacturing
- Assembly line, B
- Frame assembly, 15
- Body manufacturing: Parts, 20; Assembly, 20; Finishing and inspecting, A

Bakeries, 20

Book binding
- Folding, assembling, pasting, etc., 10
- Cutting, punching, and stitching, 20
- Embossing, 20

Breweries
- Brew house, 5
- Boiling, keg washing, and filling, 10
- Bottling, 15

Candy-making
- Box Department, 20
- Chocolate Department: Husking, winnowing, fat extraction, crushing and refining, and feeding, 10; Bean cleaning and sorting, dipping, packing, and wrapping, 20; Milling, C
- Cream-making: Mixing, cooking, and molding, 20
- Gum drops and jellied forms, 20
- Hand decorating, C
- Hard candy: Mixing, cooking, and molding, 20; Die cutting and sorting, C
- Kiss-making and wrapping, C

Canning and preserving, 20

Chemical works
- Hand furnaces, boiling tanks, stationary driers, stationary and gravity crystallizers, 5
- Mechanical furnaces, generators and stills, mechanical driers, evaporators, filtration, mechanical crystallizers, bleaching, 10
- Tanks for cooking, extractors, percolators, nitrators, electrolytic cells, 15

[1] Illuminating Engineering Society, *Recommended Practice of Industrial Lighting*, Table I, 22–27.

Clay products and cements
  Grinding, filter presses, kiln rooms, 5
  Molding, pressing, cleaning, and trimming, 10
  Enameling, 15
  Color and glazing, 20
Cleaning and pressing industry
  Checking and sorting, 20
  Dry and wet cleaning and steaming, 10
  Inspection and spotting, A
  Pressing: Machine, 20; Hand, C
  Receiving and shipping, 10
  Repair and alteration, C
Cloth products
  Cutting, inspecting, sewing: Light goods, 20; Dark goods, A
  Pressing, cloth treating (oil cloth, etc.): Light goods, 10; Dark goods, 20
Coal tipples and cleaning plants
  Breaking, screening, and cleaning, 10
  Picking, A
Construction—indoor
  General, 10
Dairy products, 20
Elevators (freight and passenger), 10
Engraving, A
Forge shops and welding, 10
Foundries
  Charging floor, tumbling, cleaning, pouring, and shaking out, 5
  Rough molding and core-making, 10
  Fine molding and core-making, 20
Garages (automobile)
  Storage, Live, 10
  Storage, Dead, 2
  Repair department and washing, C
Glass works
  Mix and furnace rooms, pressing and lehr, glass-blowing machines, 10
  Grinding, cutting glass to size, silvering, 20
  Fine grinding, polishing, beveling, etching, and decorating, C and D
  Inspection, B and D
Glove manufacturing
  Light goods: Pressing, knitting, sorting, 10; Cutting, stitching, trimming, and inspecting, 20
  Dark goods: Cutting, pressing, knitting, and sorting, 20; Stitching, trimming, and inspection, A
Hangars (aeroplane)
  Storage (live), 10
  Repair department, C
Hat Manufacturing
  Dyeing, stiffening, braiding, cleaning, and refining: Light, 10; Dark, 20
  Forming, sizing, pouncing, flanging, finishing, and ironing: Light, 15; Dark, 30
  Sewing: Light, 20; Dark, A
Ice-making (engine and compressor room), 10
Inspection
  Rough, 10
  Medium, 20
  Fine, B
  Extra fine, A
Jewelry and watch manufacturing, A
Laundries, 20
Leather manufacturing[2]
Leather working[3]
Locker rooms, 5
Machine shops
  Rough bench and machine work, 10
  Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing, 20

[2] An Illuminating Engineering Society research study of lighting in this industry is now in progress.

[3] *Ibid.*

Fine bench and machine work, fine automatic machines, medium grinding, fine buffing and polishing, B
Extra fine bench and machine work, grinding: fine work, A
Meat packing
Slaughtering, 10
Cleaning, cutting, cooking, grinding, canning, packing, 20
Milling (grain foods)
Cleaning, grinding, and rolling, 10
Baking or roasting, 20
Flour grading, 30
Offices
Bookkeeping, typing, and accounting, 30
Business machines, power driven (transcribing and tabulating): Calculators, key punch, bookkeeping, B
Conference Room: General meetings, 10; Office activities, *see* Desk work
Corridors and stairways, 5
Desk work: Intermittent reading and writing, 20; Prolonged close work, computing, studying, designing, etc., C; Reading blueprints and plans, 30
Drafting: Prolonged close work—art drafting and designing in detail, C; Rough drawing and sketching, 30
Filing and index references, 20
Lobby, 10
Mail sorting, 20
Reception rooms, 10
Stenographic work: Prolonged reading of shorthand notes, C
Vault, 10
Packing and boxing, 10
Paint mixing, 10
Paint shops
Dipping, simple spraying, firing, 10
Rubbing, ordinary hand painting and finishing; art, stencil and special spraying, 20
Fine hand painting and finishing, B
Extra fine hand painting and finishing (automobile bodies, piano cases, etc.), A
Paper box manufacturing
Light, 10
Dark, 20
Storage, 5
Paper manufacturing
Beaters, grinding, calendering, 10
Finishing, cutting, trimming, paper-making machines, 20
Plating, 10
Polishing and burnishing, 15
Power plants, engine room, boilers
Boilers, coal and ash handling, storage battery rooms, 5
Auxiliary equipment, oil switches and transformers, 10
Engines, generators, blowers, compressors, 15
Switchboards, C
Printing industries
Type foundries: Matrix making, dressing type, A; Font assembly—sorting, B; Hand casting, C; Machine casting, 20
Printing plants
Presses, C
Imposing stones, A and D
Proof reading, A
Photography
Dry plate and film, 2,000
Wet plate, 3,000
Printing on metal, 2,000
Electrotyping
Molding, finishing, leveling molds, routing, trimming, B
Blocking, tinning, C
Electroplating, washing, backing, 20
Photo engraving
Etching, staging, 20
Blocking, C

Routing, finishing, proofing, B
Tint laying, A
Receiving and shipping, 10
Rubber manufacturing and products[4]
Sheet metal works
Miscellaneous machines, ordinary bench work, 15
Punches, presses, shears, stamps, welders, spinning, medium bench work, 20, D
Tin-plate inspection, B and D
Shoe manufacturing (leather)
Cutting and stitching: Cutting tables, 10; Marking, buttonholing, skiving, sorting, vamping, and counting — light materials, 20, dark materials, C — Stitching — light materials, C, dark materials, B
Making and finishing: Stitching, nailing, sole laying, welt beating and scarfing, trimming, welting, lasting, edge setting, slugging, randing, wheeling, treeing, cleaning, spraying, buffing, polishing, embossing — light materials, 20, dark materials, C
Storage, packing, and shipping, 10
Shoe manufacturing (rubber)
Washing, coating, mill-run compounding, 10
Varnishing, vulcanizing, calendering, upper and sole cutting, C
Sole rolling, lining, making and finishing processes, C
Soap manufacturing
Kettle houses, cutting, soap chip and powder, 10
Stamping, wrapping and packing, filling and packing soap powder, 20
Steel and iron manufacturing
Billet, blooming, sheet bar, skelp and slabbing mills, 5
Boiler room, power house, foundry and furnace rooms, 5
Hot-sheet and hot-strip mills, 10
Cold-strip pipe, rail, rod, tube, universal plate and wire drawing, 10[5]
Merchant and sheared-plate mills, 15[5]
Tin-plate mills: Hot-strip rolling and tinning machine department, 10; Cold-strip rolling, 15
Inspection: Black plate, C; Bloom and billet chipping, C; Tin-plate and other bright surfaces, B and D
Machine shops and maintenance department: Repair shops—rough bench and machine work, 10, medium bench and machine work, 20, fine work (buffing, polishing, etc.), B, extra fine work, A
Blacksmith shop, 10
Laboratories (chemical and physical), 15
Carpenter and pattern shop, 20
Storage, 2
Stone crushing and screening
Belt-conveyor tubes, main-line shafting spaces, chute rooms, inside of bins, 5
Primary breaker room, auxiliary breakers under bins, 5
Screens, 10
Storage battery manufacturing
Molding of grids, 10
Store and stock rooms
Rough bulky material, 5
Medium or fine material requiring care, 10
Structural steel fabrication, 10
Sugar grading, 30

[4] *Ibid.*

[5] In these areas many machines require one or more supplementary lighting units mounted on them in order effectively to direct light toward the working points.

Testing
- Rough, 10
- Fine, 20
- Extra fine instruments, scales, etc., A

Textile mills (cotton)
- Opening, mixing, picking, carding, and drawing, 10
- Slubbing, roving, spinning, 20
- Spooling, warping on comb, 20
- Beaming, and slashing on comb: Grey goods, 20; Denims, B
- Inspection: Grey goods (hand turning), C; Denims (rapidly moving), A
- Automatic tying-in, weaving, B
- Drawing-in by hand, A

Silk and rayon manufacturing
- Soaking, fugitive tinting, and conditioning or setting of twist, 10
- Winding, twisting, rewinding, and coning, quilling, slashing, 30
- Warping (silk or cotton system): On creel, on running ends, on reel, on beam, on warp at beaming, C
- Drawing-in: On heddles, A; On reed, A
- Weaving: On heddles and reeds, 5; On warp back of harness, 10; On woven cloth, 30

Woolen
- Carding, picking, washing, combing, 10
- Twisting, dyeing, 10
- Drawing-in, warping: Light goods, 15; Dark goods, 30
- Weaving: Light goods, 15; Dark goods, 30
- Knitting machines, 20

Tobacco products
- Drying, stripping, general, 10
- Grading and sorting, A

Toilets and wash rooms, 5

Upholstering (automobile), Coach Furniture, 20

Warehouse, 5

Woodworking
- Rough sawing and bench work, 10
- Sizing, planning, rough sanding, medium machine and bench work, gluing, veneering, cooperage, 20
- Fine bench and machine work, fine sanding and finishing, C

LIGHTING RECOMMENDATIONS FOR THE MORE DIFFICULT "SEEING" TASKS, AS INDICATED BY A, B, C, AND D IN THE FOREGOING TABLE

GROUP A

These seeing tasks involve (*a*) the discrimination of extremely fine detail under conditions of (*b*) extremely poor contrast (*c*) for long periods of time. To meet these requirements illumination levels of more than 100 foot-candles are recommended.

To provide illumination of this order a combination of at least 20 foot-candles of general lighting plus specialized supplementary lighting is necessary. The design and installation of the combination systems must not only provide a sufficient amount of light but also must provide the proper direction of light, diffusion, eye protection,

and insofar as possible must eliminate direct and reflected glare as well as objectionable shadows.

GROUP B

This group of visual tasks involves (*a*) the discrimination of fine detail under conditions of (*b*) a fair degree of contrast (*c*) for long periods of time. Illumination levels of from 50 to 100 foot-candles are required.

To provide illumination of this order a combination of 10 to 20 foot-candles of general lighting plus specialized supplementary lighting is necessary. The design and installation of the combination systems must not only provide a sufficient amount of light but also must provide the proper direction of light. Diffusion, eye protection, and insofar as possible must eliminate direct and reflected glare as well as objectionable shadows.

GROUP C

The seeing tasks in this group involve (*a*) the discrimination of moderately fine detail under conditions of (*b*) better-than-average contrast (*c*) for intermittent periods of time.

The level of illumination required is of the order of 30 to 50 foot-candles and in some instances it may be provided by a general lighting system. Oftentimes, however, it will be found more economical and yet equally satisfactory to provide from 10 to 20 foot-candles from the general system and the remainder from specialized supplementary lighting. The design and installation of the combination systems must not only provide a sufficient amount of light but also must provide the proper direction of light, diffusion, eye protection, and insofar as possible must eliminate direct and reflected glare as well as objectionable shadows.

GROUP D

The seeing tasks of this group require the discrimination of fine detail by utilizing (*a*) the reflected image of a luminous area or (*b*) the transmitted light from a luminous area.

The essential requirements are (1) that the luminous area shall be large enough to cover the surface which is being inspected and (2) that the brightness be within the limits necessary to obtain comfortable contrast conditions. This involves the use of sources of large area and relatively low brightness in which the source brightness is the principal factor rather than the foot-candles produced at a given point.

Appendix IV

SOME NATIONAL ORGANIZATIONS CONCERNED WITH INDUSTRIAL WELFARE

The following organizations are listed because they are in some way concerned with industrial accident prevention and also health promotion activities in the United States. Because of the international situation it was not considered feasible to include the names of international organizations, although a number of them whose central offices are located in the Western Hemisphere are of great value to the industrial welfare movement in the United States.

Aeronautical Chamber of Commerce of America, Inc.
30 Rockefeller Plaza
New York City

American Association of Industrial Physicians and Surgeons
540 North Michigan Ave.
Chicago, Ill.

American Association of Motor Vehicle Administrators
Washington, D. C.

American Association of State Highway Officials
1220 National Press Bldg.
Washington, D. C.

American Automobile Association
Pennsylvania and 17th St.
Washington, D. C.

American College of Surgeons
40 East Erie St.
Chicago, Ill.

American Farm Bureau Federation
58 East Washington St.
Chicago, Ill.

American Foundrymen's Association
222 West Adams St.
Chicago, Ill.

American Gas Association
420 Lexington Ave.
New York City

American Institute of Electrical Engineers
33 West 39th St.
New York City

American Legion
777 N. Meridian St.
Indianapolis, Ind.

American Medical Association
Council on Industrial Health
535 N. Dearborn St.
Chicago, Ill.

American Museum of Safety
60 E. 42d St.
New York City

American National Red Cross
17th St.
Washington, D. C.

American Petroleum Institute
50 W. 50th St.
New York City

American Public Health Association
1790 Broadway
New York City

American Public Works Administration
1313 E. 60th St.
Chicago, Ill.

American Road Builders Association
938 National Press Bldg.
Washington, D. C.

American Society of Mechanical Engineers
29 W. 39th St.
New York City

American Standards Association
29 W. 39th St.
New York City

American Transit Association
292 Madison Ave.
New York City

American Trucking Association, Inc.
1013 – 16th St., N. W.
Washington, D. C.

Associated General Contractors of America
Munsey Bldg.
Washington, D. C.

Association of American Railroads
Transport Bldg.
Washington, D. C.

Association of Iron and Steel Engineers
Empire Bldg.
Pittsburgh, Pa.

Automotive Safety Foundation
366 Madison Ave.
New York City

Boy Scouts of America
2 Park Ave.
New York City

Bureau of Explosives
30 Vesey St.
New York City

Chamber of Commerce of the United States
1615 H St., N. W.
Washington, D. C.

Commercial Investment Trust
1 Park Ave.
New York City

Edison Electric Institute
40 Lexington Ave.
New York City

Eno Foundation of Highway Traffic Regulation
Saugatuck, Conn.

General Federation of Women's Clubs
1734 N St., N.W.
Washington, D. C.

Highway Education Board
Pan American Bldg.
Washington, D. C.

Highway Research Board of the National Research Council
2101 Constitution Ave., N.W.
Washington, D. C.

Holmes Safety Association, Joseph A.
United States Bureau of Mines
Washington, D. C.

Illuminating Engineering Society
51 Madison Ave.
New York City

Institute of American Meat Packers
59 E. Van Buren St.
Chicago, Ill.

Institute of Traffic Engineers
60 John St.
New York City

National Association of Practical Refrigerating Engineers
228 N. La Salle St.
Chicago, Ill.

National Association of Taxicab Owners
500 N. Dearborn St.
Chicago, Ill.

National Board of Fire Underwriters
85 John St.
New York City

National Child Welfare Association
70 Fifth Ave.
New York City

National Conference on Street and Highway Safety
Bureau of Public Roads
Washington, D. C.

National Congress of Parents and Teachers
1201 16th St., N.W.
Washington, D. C.

National Conservation Bureau
60 John St.
New York City

National Crushed Stone Association
1735 14th St., N.W.
Washington, D. C.

National Education Association
1201 16th St., N.W.
Washington, D. C.

National Electrical Manufacturers Association
155 S. 44th St.
New York City

National Fire Protection Association
60 Batterymarch St.
Boston, Mass.

National Founders Association
29 South La Salle St.
Chicago, Ill.

National Grange
970 College Ave.
Columbus, Ohio

National Highway Users Conference
National Press Bldg.
Washington, D. C.

National Industrial Conference Board
247 Park Ave.
New York City

National Safety Council, Inc.
20 N. Wacker Drive
Chicago, Ill.

National Society for the Prevention of Blindness, Inc.
1790 Broadway
New York City

Outdoor Advertising Association of America, Inc.
165 W. Wacker Drive
Chicago, Ill.

Portland Cement Association
33 W. Grand Ave.
Chicago, Ill.

Society of Automotive Engineers
29 W. 39th St.
New York City

Society of Grain Elevator Inspectors
208 S. LaSalle St.
Chicago, Ill.

United States Conference of Mayors
730 Jackson Pl., N.W.
Washington, D. C.

United States Junior Chamber of Commerce
410 Mayfair Hotel
St. Louis, Mo.

Veterans of Foreign Wars
Broadway at 34th St.
Kansas City, Mo.

Yale University, Bureau for Street Traffic Research
New Haven, Conn.

Industrial commission of various states

Insurance Companies

United States Government, Washington, D. C.
Bureau of Census
Bureau of Labor Statistics
Bureau of Mines
Bureau of Public Roads
Bureau of Navigation and Steam Boat Inspection
Civil Aeronautics Authority
Division of Labor Standards
Interstate Commerce Commission
National Advisory Committee on Aeronautics
National Bureau of Standards
Office of Education
Public Health Service

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to the owners and managers of industry and their executives and sub-executives; to engineers; to workers both as individuals and groups; to government administrators; to public and private welfare agencies which have any contacts whatsoever with industry or with industrial workers; and finally, and more directly, to safety engineers, safety inspectors, industrial physicians, ophthalmologists, general physicians, surgeons, nurses and regional sight-conservation agencies.

This book provides the means by which all this time, money, pain and human misery can be saved. It contains a complete synthesis of what is known on the subject. It is not a swivel-chair book, but the direct product of many personal investigations of industrial plants, interviews with industrial workers, foremen, safety directors, doctors and nurses, and finally with those whose eyes have been injured. Nor is this book the product of a single mind but instead the result of the collaboration of hundreds of safety engineers, physicians, surgeons, executives, government officials, insurance men, safety device manufacturers, dealers and consumers.

It not only lays bare the eye hazards present in industry and occupations of all sorts, but also shows how these hazards may be eliminated or how the workers can be guarded against those that cannot be eliminated.

This is a handbook for safety engineers, safety inspectors and all connected actively in accident prevention generally and sight conservation in particular.

It is also a textbook for engineering schools, vocational training advisors and all others engaged in preparing youth for work in industry.

Conservation of the eyes of American workingmen is as vital to national defense as is the building of armament and the training of men to use defense equipment.

EYE HAZARDS IN INDUSTRY

BY LOUIS RESNICK

Published for the National Society for the Prevention of Blindness